

MODEL ENGINEERS'

WORKSHOP

THE PRACTICAL HOBBY MAGAZINE



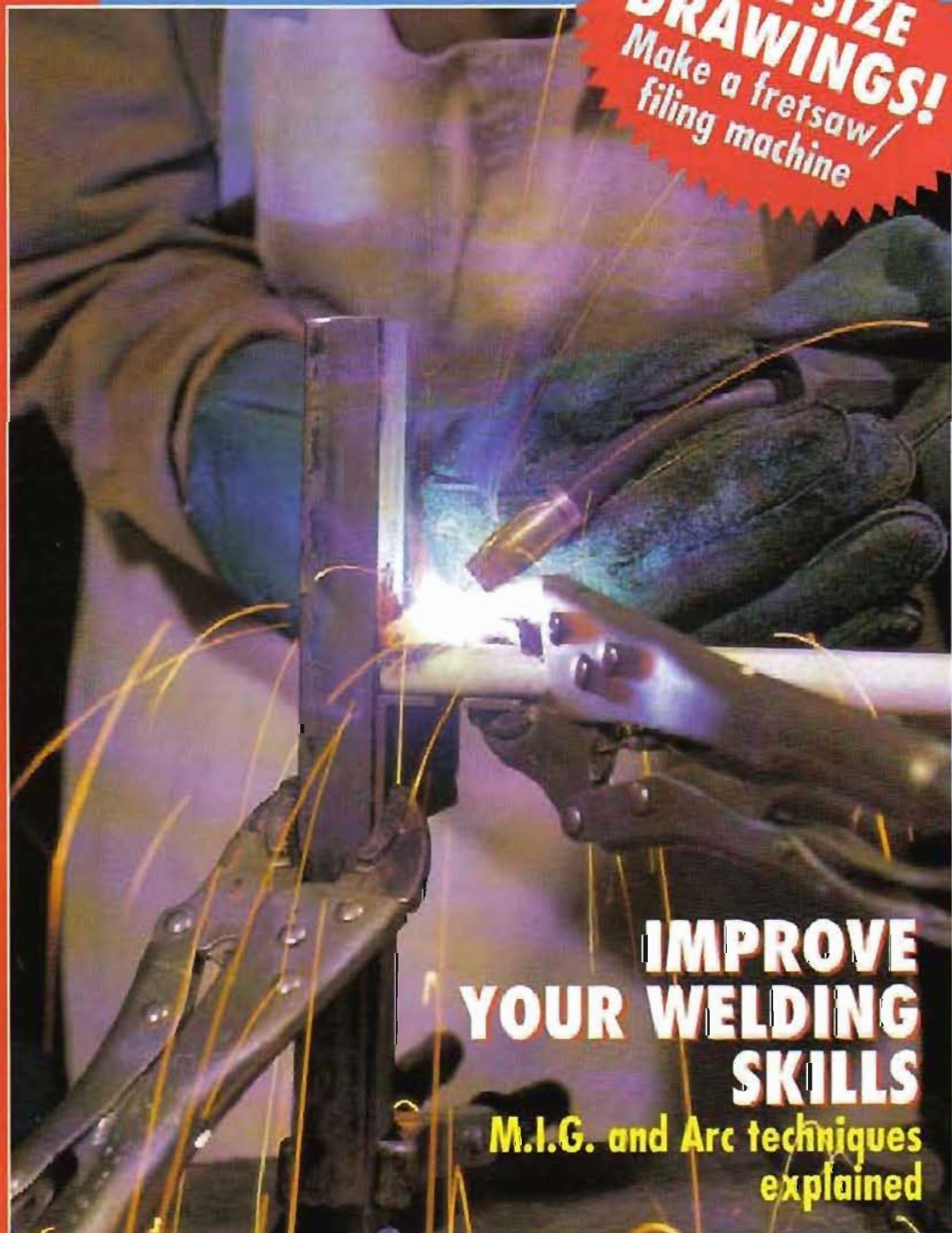
HOBBYMAT EXTRAS
To improve your lathe



A BETTER VICE
Add to its accuracy



BACK TO SCHOOL!
Rewards of evening classes



**FULL SIZE
DRAWINGS!**
Make a fretsaw/
filing machine

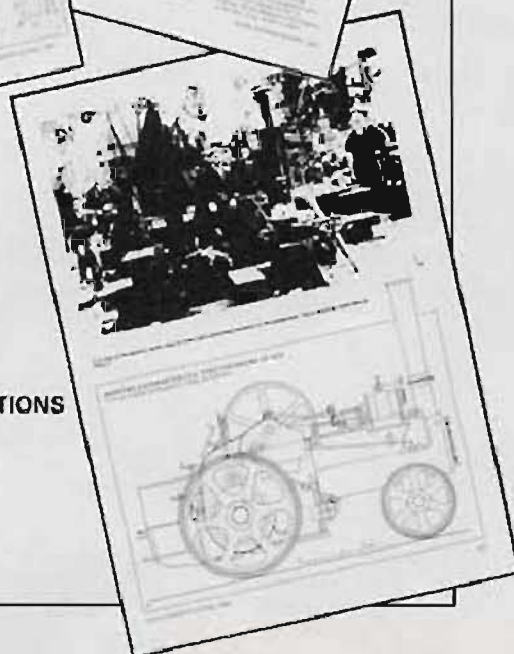
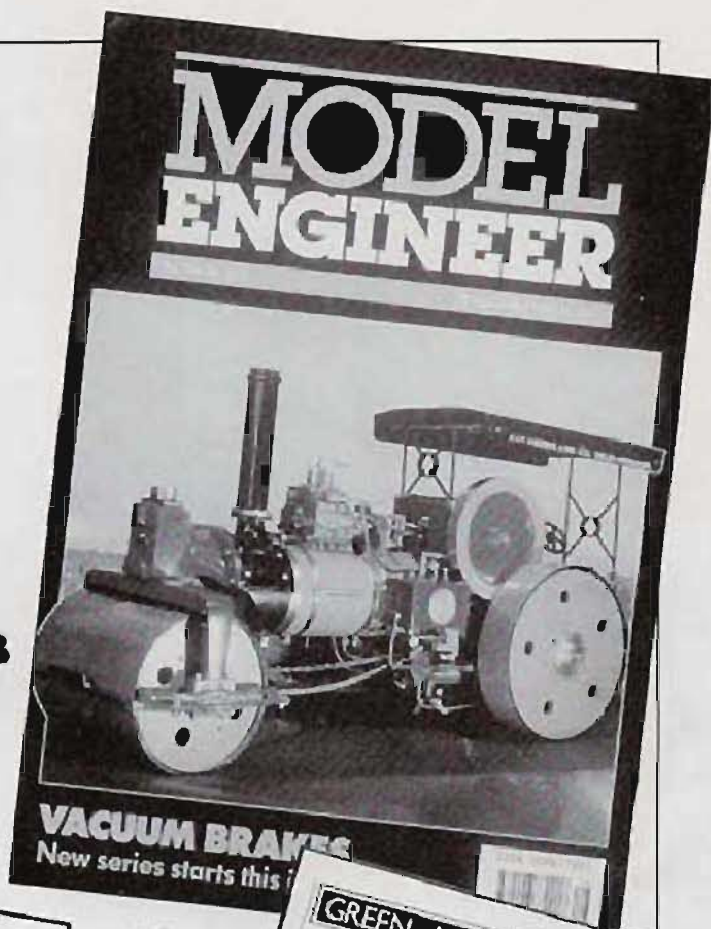
**IMPROVE
YOUR WELDING
SKILLS**
M.I.G. and Arc techniques
explained

**TAKING OUT
THE SURPLUS**

A technique for awkward workpieces



**SOMETHING
TO LOOK
FORWARD
TO...**
...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription - a mere £33.60 for UK readers (overseas rates and airmail details on request).

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CONTENTS

12



Page 57

- 46** **TRADE COUNTER**
New products and sourcing materials
- 49** **IMPROVING A MILLING VICE**
An indifferent tool converted to high precision
- 58** **M.I.G. AND ARC WELDING**
Introductions to two useful forms of metal joining
- 64** **MAKING A FOUR JAW CHUCK**
We've done the little, now the large

- 5** **ON THE EDITOR'S BENCH**
Harold Hall's commentary

- 7** **SCRIBE A LINE**
Readers' views and ideas

- 12** **A FRETSAW/FILING MACHINE/JIGSAW**
Build this versatile space saver

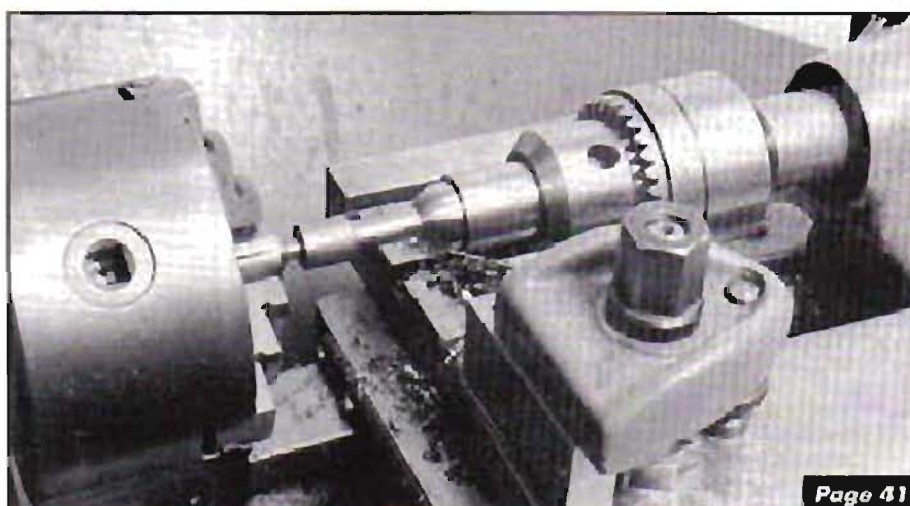


Page 67

- 15** **MORE MUSEUMS OF INTEREST**
History of technology revealed

- 17** **JACK THE RIBBER**
Or, How a hydraulic press developed

- 23** **A WHEEL ENGINE FROM SCRAP**
Wheelcutting on a budget



Page 41

- 24** **TURNING BALL HANDLES**
We made the balls last time - now we finish the job

- 28** **ATTACHMENTS FOR THE HOBBYMAT**
Improved versatility for a smaller machine

- 30** **MACH '92**
A brief look at an exhibition of interest

- 31** **TRYING THE UNIVERSAL BENDER**
Its limitations are those you care to invent

- 33** **A MILLING MACHINE STAND**
Try out your M.I.G. welding on this beauty

- 34** **BACK TO COLLEGE**
The advantages of attending evening classes

- 38** **MILLING FOR BEGINNERS**
Part 3 of a series aimed at the novice

- 43** **MAKING A GARDEN GATE**
A chance to try out your welding skills

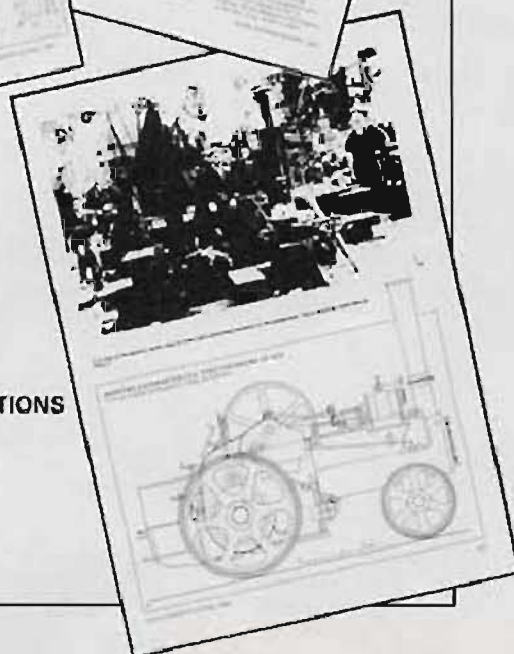
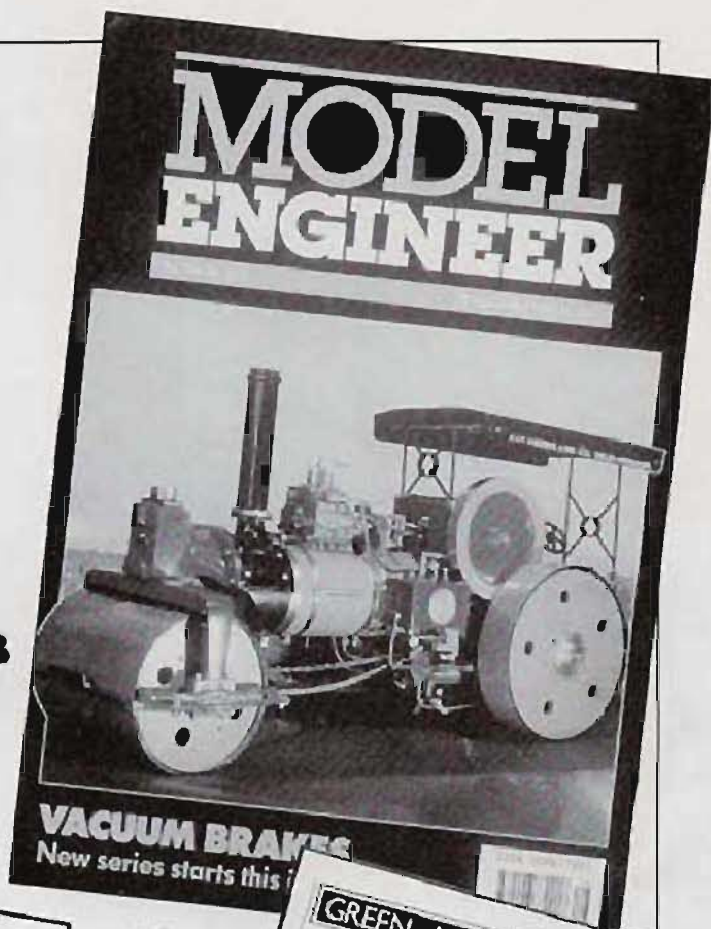
- 72** **MAKING DRILLS FROM FLAT STOCK**
Tips to get you out of trouble

- 76** **ADVERTISER'S INDEX**



Page 50

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Harold Hall

ON THE EDITOR'S BENCH

This issue marks a minor milestone for me as editor of *Model Engineers' Workshop* being the sixth I have been responsible for, therefore it completes one year. The year has been a very rewarding one for me and your letters of encouragement have gone a long way to make this so. It is very nice to get so many letters complimenting *M.E.W.* and so few critical of its content.

I can't help feeling though that many readers, even if happy with *M.E.W.* in general, would like some aspect changed or type of article included or left out. Please do feel free to write and let me know your thoughts. Your letter will be acknowledged, though probably not in detail as the amount of correspondence received makes this difficult, not least because my speed on the word processor still leaves a lot to be desired.

MACH '92

Early May saw the International Exhibition of Machine Tools and Manufacturing Technology, *MACH '92*, being held at the National Exhibition Centre, Birmingham. This was a massive exhibition, apparently much larger than many of its counterparts, typically that held in Tokyo. I attended considering that it may bring to light items of more than just general interest to readers of this magazine. This was not so, and as a result the report elsewhere in this issue is very brief.

The exhibition would though be of considerable interest if visited in the manner one would attend a museum. Unfortunately for me, my aim to view the whole exhibition in the hope of finding something for this magazine, left little time for studying in detail any of the very many interesting machines on display.

Safety

One aspect of *M.E.W.* articles that frequently appear in correspondence is that of safety. I am working on this, but as may be anticipated it is not easy to comply with all the correspondents wishes. In any case slavish compliance with the rather general industrial regulations may not always be the best, when situations can be viewed individually in ones own workshop. I often consider that in my own case, removal of the very heavy high level guard to enable me to change the speed of my mill/drill, constitutes a much greater hazard than that

presented by leaving it off. I have already dropped it once, fortunately I do wear safety shoes, I often wonder if our correspondents on the subject of safety do, they are never mentioned. An article to enable the easy removal of these heavy guards, as were particularly fitted to the earlier mill/drills, is in the course of preparation.

A reader has sent me a cutting from *Western Mail* containing a warning given by the Mid Glamorgan Fire Service. This refers to two serious accidents which have occurred locally, one of which was fatal. These were due to DIY activities being carried out in the garage, resulting in petrol vapour fires. The article indicated that few people realised that when a car had been standing for some time, petrol vapour would frequently be present.

The recent survey showed that many readers workshops are contained in the garage and it is obvious that considerable diligence is required under these conditions. A fire extinguisher should be considered an essential item of equipment, as it should in any workshop.

14½deg. Pressure Angle Gearing

Following a request from a reader for values relating to cutting gears with a 14½deg. pressure angle, Don Unwin has provided the required table of values for him. Anyone wishing to have a copy of this should send in a stamped addressed envelope, marked 14½PA.

Students

It is interesting to note from correspondence received that *M.E.W.* is read in colleges, both by the lecturers and by full time students. An example of this can be seen in *Scribe a Line* this issue, explaining that a group of students have adopted the recent digital readout as a group project.

Whilst commenting on this item, a reader from Canada has attempted to make this but found it impossible to purchase the main counter IC in Canada or the USA. Any reader who is having problems with purchasing this or the PCB should please write to me and I will try to help. The digital readout article is still generating much interest.

Returning to the question of colleges, another reader in *Scribe a Line* is exalting the benefits of attending college for their so called Model Engineering classes. This is also the subject of a brief article *Back to College* in this issue. I would urge you to consider the possibility of attending such a class, why not give it a try for a term?

MIG Welding

A major feature of this article is the inclusion of the MIG welding article. This makes reference to an article on welding published in the Winter 1990/91 issue. As this is an early issue many readers will not have a copy and an abbreviated reprint is included for their benefit. Whilst mentioning early issues do remember that I would be happy to receive any of these which you decide to dispose of, please do not just throw them away.

To complement the MIG welding article a number of constructional items which provide some welding activity are also to

be found, these include the milling machine stand and the garden gate. The trade pages also include some welding related items.

The review of the universal bender distributed in the UK by CZ Scientific Instruments Ltd, describes an item that would be very helpful in bonding parts for the garden gate, though it would not be able to cope with the larger sections perhaps.

Mill/drill down feed modification

In the June/July issue an article was published giving the design for a modification to a mill/drill, the purpose of which was to overcome the common problem of backlash in the down feed mechanism. The author in his original correspondence to me referred also to another method published in *Model Engineer* 20 Jan 1989 by Mr G.F.A.M. Turner. It had been my intention to refer to this as a postscript to the June/July article. The system required two Tensator springs, which I considered might present some problem for the average reader to make. I have since received a letter from another reader who mentions the *M.E.* article and points out that the Tensator springs can be purchased from Essel Engineering (0277 659774). With these available it is a good and very simple system to adopt.

Raw materials

Frequently readers comment on the problem of obtaining raw materials, particularly in the larger sizes and in small quantities. Included for the first time in the Sources of Supply feature in Trade Counter, is a request for details of local suppliers who will supply to callers small quantities of steel etc, and with a nil or very low minimum order charge. If you know of such a supplier, please send in the details.

This months request for articles

The request published in the Feb/Mar copy of *MEW* for an article on metal spinning has not resulted in any offers. I am sure that there must be some readers who have adopted this manufacturing technique and could provide an article, what about it?

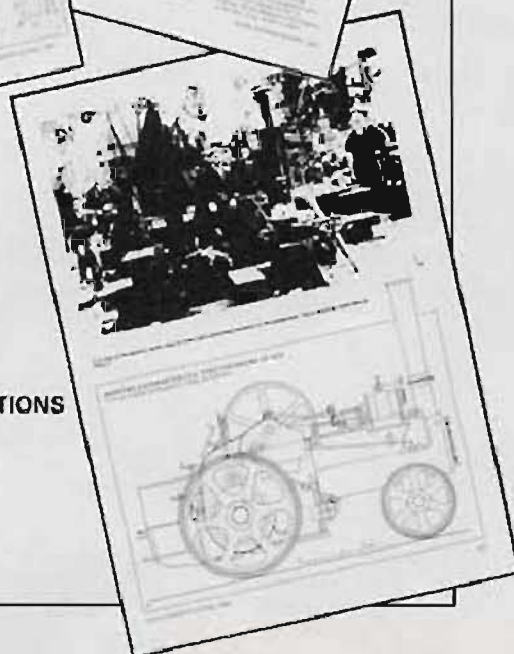
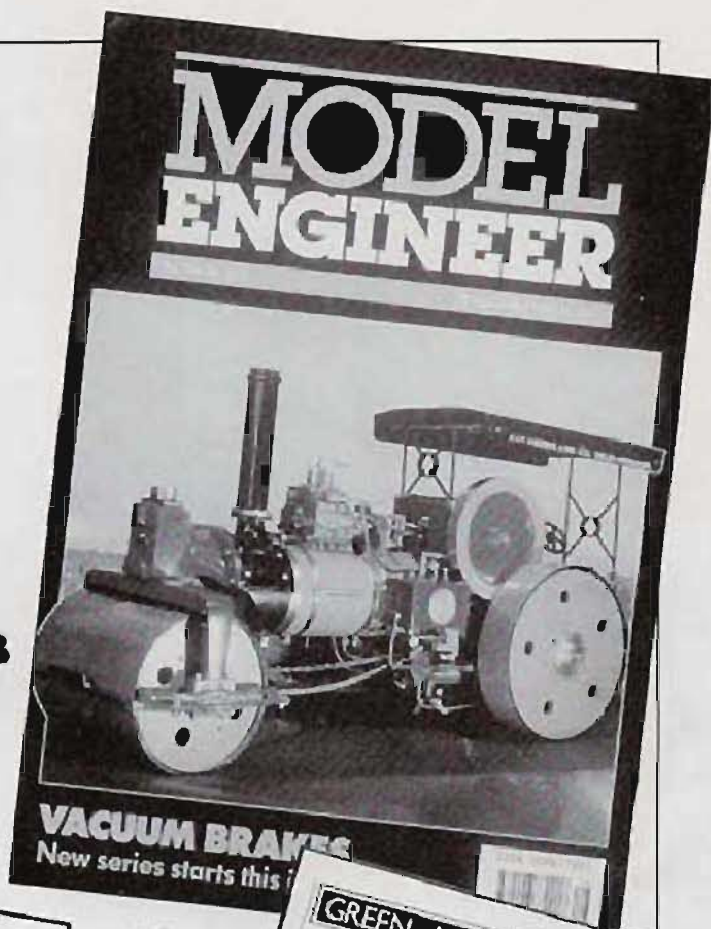
If any reader has experience in metal spinning but feels unable to produce an article it may be possible to make it a joint effort with myself. This would depend on the individual living say within 150 miles of Hemel Hempstead, which would make it possible for me to make a visit. If further, it may still be possible, but would have to be arranged to coincide with other reasons for visiting the area.

In the last issue a request was made for an article on an electric furnace. I would also be happy to receive an offer of an article on an electric oven for hardening and tempering etc.

Often seen in industry for the quick marking of items including hardened steel, are spark engravers. Can any reader provide details for making such an item?

Copies of articles previously published and mentioned above can be obtained £1.50 for UK readers and 2.00 overseas readers. Requests should be sent to the Photostat Service, Argus Specialist Publications, Boundary Way, Hemel Hempstead, Herts HP2 7ST.

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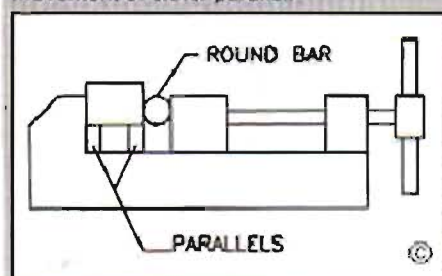
SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in Model Engineers' Workshop are always welcome

Jaw lift

From Mr Cambridge of Meopham Kent
With reference to your article, Milling for Beginners may I offer this tip to combat jaw lift.

Place the work to be machined on parallels and place a round bar between the sliding jaw and the workpiece. Nip the vice up and tap the work piece down until both parallels are trapped. Repeat the procedure until the work is secure with no movement of either parallel.



I served my apprenticeship in the 1950's and this was standard practice in the milling shop. I do hope it may be useful to others if this overcomes the problem.

I would like to add that I have learnt so much from M.E.W. and it is little things as well, like cross drilling from the Rev. R S Hatfull that all add to make life easy and hopefully more accurate.

I enjoyed the first edition of M.E.W. and every one since. Keep them going.

Chucks

M. Van Der Herten Ludo of Antwerp Belgium sends this interesting letter regarding the chuck featured in recent scribe a line pages.

Regarding M.E.W 8 page 8 and M.E.W. 10 page 8 Mr Gunstons chuck. I am happy to let you know that a similar chuck is still available from the German "Rohm" brand namely the "Gema" type of chuck with B16 cone and an opening of 1-13mm. It is of the ring type as Tyzacks no TW1987.

I subscribe to M.E. and M.E.W. and am always happy to learn from other people's experiences. I have a small engineering business and find new approaches always interesting.

Wind generators

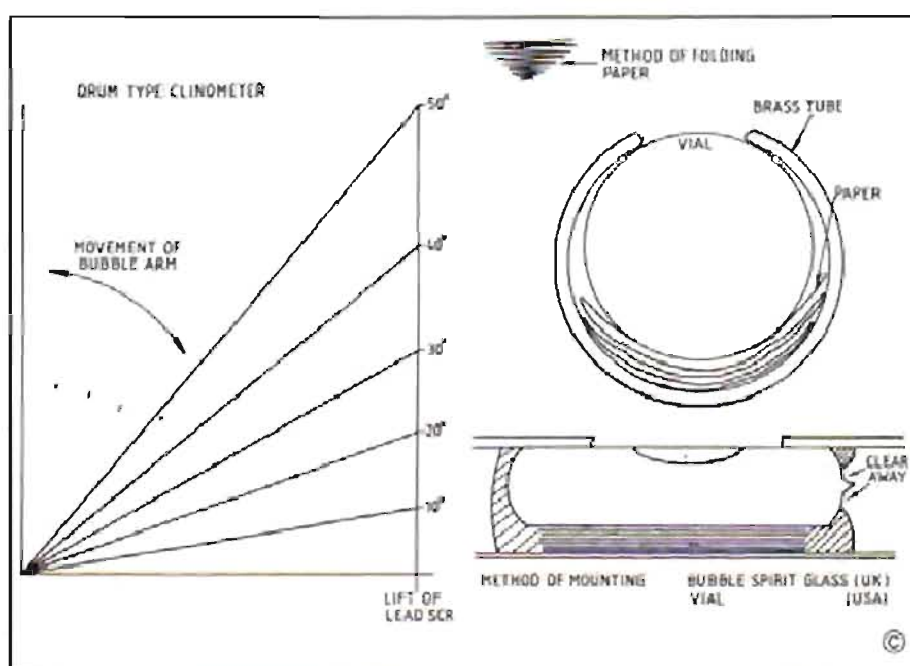
Mr W. Curry of Pembroke seeks help with the idea of a wind generator.

I have long been thinking of making a 12 or 24 volt wind generator using an automobile alternator, which would supply power to a small workshop. Any ideas would be welcome.

Encouragement from the young

P Crowley a student and project team leader at the Oxford College of Further Education sends this encouraging letter.

My colleagues and I are a group of students at this college studying electrical/electronic/mechanical subjects. As a project for our course we have chosen to attempt to build the digital readout which appeared in your December 91/January 92 and February/March 92 issues.



Clinometers

Mr Towll of Telford replies to Mr Thomson's letter (overleaf) as follows.

With reference to Mr R.F. Thomson's letter he is correct in his reasoning on the need for a calibration chart. Although the lift of the drum is linear the extended line of the radius is not as can be seen in the drawing.

This can be confirmed by comparing the measurement of a small angle division against the same angular division at say the highest on the drum. This discrepancy is overcome by shaping the shoe into a cam form as the raising of the drum brings into contact a different area of the shoe. Due to the difficulty in shaping the shoe, and errors caused by wear, repair and use a calibration chart is required.

Initially the drum was calibrated to the shoe but due to the above a calibration sheet was required. I have seen one drum clino dated 1808, they are not modern in design. The shoe was graduated by hand, a long drawn out job. The verticality of the lead screw is important, misalignment from the vertical produces a wave error in reading. Under the drum bearing upon the

lead screw are usually three spring loaded anti wear inserts.

All these comments are assuming the clino of Mr Thomson is an ex MOD inspectors clino. The later mills version was a quadrant type giving linear reading graduations and the design eliminated the bugbears of the drum type.

Passing on to the article of the engineers level. The vials as stated are very expensive, therefore care should be taken in mounting these.

A method used by instrument makers is. - Fold a piece of drawing paper that has been cut into a strip about the width of the vial, in a concertina fashion, each fold being smaller than the last, offer this and the vial to the tube. By cutting off folds starting from the largest a nice smooth push in fit can be obtained. This paper provides a white background and also buffers the vial from knocks.

The vial is now plastered in, but the pip of the vial has the plaster removed this will prevent the expansion of the vial cracking it.

Hoping these comments and tips are of interest to the readers.

Clinometers

Mr Thomson of Paignton writes again (see Feb/Mar issue) the subject of clinometers.

I was most interested to read the comments made by Mr Towll as contained in his letter (M.E.W. - April/May 1992), on the subject of artillery type sine bar clinometers, which I had described earlier. Details of his method for testing the accuracy of these instruments were most welcome, and needless to say I have since implemented such investigation of my own clinometer, with encouraging results.

For purposes of dividing in the lathe, I was not very concerned about orthogonality between the two faces, since only one of these is used, and the settings are of a differential nature only. Nevertheless, as the instrument is used for a multitude of other purposes in the workshop, confirmation of accuracy in that direction was most welcome. On the other hand, the second point surrounding misalignment of distortion of the quadrant, relative to the faces, was more important from my standpoint, because this could clearly affect differential accuracy. In the event however, I can now be more confident on that score also.

I did feel reasonably sure that no serious errors would be revealed, bearing in mind that over many years I had machined gears with large numbers of teeth, without detecting any material placement errors, under careful microscopic examination. Of course, I cannot claim never to have produced a rogue gear, although fortunately, most such errors have been directly traceable to lack of diligence whilst setting, or carelessness in transferring figures from the calculator to the clinometer. It has always been my practice to make a list of angular settings, in advance of machining. Then, if the first cut be marked, it becomes a simple matter to refer back to the list, in the event of a suspected tooth cut placement error. It is necessary to list only the first 45 degree span of settings, since subsequent spans are merely repeats. Of course, it is vitally important to take extra care when re-setting the assembly to zero at the end of each 45 deg. period since the incidence of error is far more likely during these operations.

With regard to Mr Towll's thoughts on my other clinometer, of the 'end lift' type. Whilst he is no doubt right about its intended function, his reference to use in conjunction with a separate calibration chart did puzzle me somewhat, since it bears quite clear micrometer, and linear calibrations, in minutes and degrees, in its own right.

I can only surmise, that this separate calibration chart pertains to the correction of errors which arise because whilst the instrument calibration itself is linear, i. e. proportional, the angle, and distance travelled by the lift screw nut, are not related in direct proportion, but rather become a function of the angle itself. I further conjecture, that for angles less than 10 degrees, the corrections will be quite small, but nevertheless may be significant when compared to ultimate resolution, particularly for angles close to 10 degrees.

If this be the case, confirmation, and/or enlargement by Mr Towll, would be much appreciated.

In conclusion may I also extend my

thanks to Mr Whatmore for his contribution to the history of the sine bar type clinometers used in artillery.

Incidentally, since writing my earlier letter, I have had the good fortune to meet a gentleman at my local "Brixham Model Engineer & Craft Society", who is clearly very well versed in artillery history/engineering. In fact, he has in his possession a substantial military volume on artillery, which describes sine bar clinometers in very great detail. Apparently, some of the later 'Marks' were calibrated in angular mils, rather than in Degrees/Minutes/Seconds, one mil being equal to 1/1000 Radian, which in turn equates to 3.438 (rounded) minutes. Alternatively, one right angle is equal to 1570.795 mils. This information could be useful to any reader confronted with such an instrument furnished with an apparently cryptic calibration scale.

Square shanked drills

Another letter regarding older items of tooling has resulted in a large post bag, twelve in all. This was the request from Mr Sterland for identification of the purpose of his drills with square tapered shanks.

I cannot acknowledge each writer by name but am indebted to Mr M. Trodd of Milford Haven for the following letter, also to both Mr W. Curry of Pembroke and Mr J. Arnold of Upwell for providing the details from the Buck and Hickman 1964 catalogue.

Mr R. King of Newbury also provided a copy from a 1928 catalogue from Farmer Stedall of Clerkenwell. (Is this company still trading - Ed?).

A number of readers refer to the process being very hard work having used them in the past. This is not surprising as drills were available up to 2in. diameter. In 1928 drills 1-1/2in. dia. were £1.00 each in carbon and almost £3.00 in High Speed Steel.

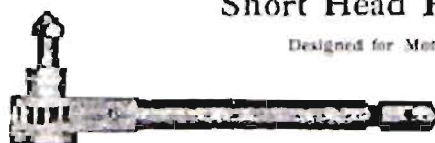
A Mr Jennings of Sheffield has written indicating that there is a firm in Sheffield which has the name Richard Carr and Company Ltd, mentioned by Mr Stearland, on the roof of its building, so it would appear that it is still trading.

Re. the letter about odd drills by Mr Sterland. When I was serving my time in the 40's on Milford Docks, many of the ships had no power aboard (they either had no steam up to run their generators nor were they connected to ship-to-shore power), so everything was hand powered.

BUCK & HICKMAN, LTD.,

Short Head Ratchet Brace Fig. 3045

Designed for Motor Cars and Confined Spaces



Length, 10 in.
Shortest length of Head, 2 1/2 in.
This Brace is furnished with two centres.

The Square hole is adapted for cropped Morse Bit Stocks.

PRICE 77/6 each

Wrought Steel Ratchet Brace

Fig. 1731. For Boiler Plate work

Powerful and compact for drilling in narrow spaces.

Total length, 15 x 3/4 in. across head. Drill hole, 1/2 in. square.

PRICE 94/- each



We can supply Extra Short or Stumpy Drills to suit.



Drilling Pillars Fig. 2040

Admiralty Pattern

Specially adapted for use on board ships and as used by the Admiralty.

No. 1 Pillar

1 1/2 in. diam. x 21 in. high

PRICE £5 5 0 each

No. 2 Pillar

2 in. diam. x 32 in. high

PRICE £9 10 0 each

"Universal" Drilling Pillars

Fig. 4444

Specially designed to overcome the necessity of making the many special pillars for varied work.

With the exception of the chain for pipe use, no additional parts are required to render it adaptable for any shape work.

No. 1

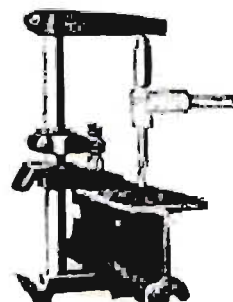
Upright, 1 1/2 in. dia. x 24 in. long.
Length of arm, 11 in.

PRICE £7 0 0 each

No. 2

Upright, 1 1/2 in. dia. x 19 1/2 in. long.
Length of arm, 10 in.

PRICE £8 0 0 each



2, WHITECHAPEL ROAD, LONDON, E. 1.

For drilling holes in steel, ratchet drills were used and the ratchet handles accepted tapered square shank drills, so it is my guess that is what Mr Sterland is talking about.

To drill a hole at a location a drill stand of a sort was fastened near the location of the hole by what ever means was available, and a sliding arm was adjusted directly over the ratchet and required drill in an axial line, then a pointed adjusting screw at the opposite end to the drill was lightly tightened against the sliding arm, and the ratchet was tapped till the drill was at 90 degrees to the work (mostly by eye) then from then on it was all arm work using the ratchet.

After the main body of the drill started to bite into the metal tightening of the adjusting screw would keep pressure on the drill, needless to say the drills had to be kept well sharpened, especially large drills, it was very hard work indeed.

I expect many of the older Boilermakers will have written into you on the subject, especially about the drill stand, which I unfortunately can't remember the correct name for.

I hope this has answered Mr Sterland's query to some extent.

Mervyn Trodd
Milford Haven

White metalling of bearings

Mr Slade of Henley-on-Thames gives some details on the subject of white metalling, a full article on this matter will be published in the next issue.

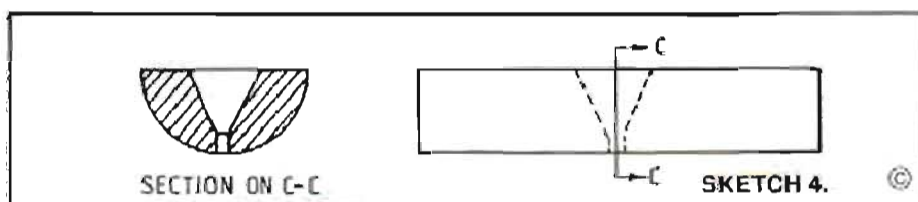
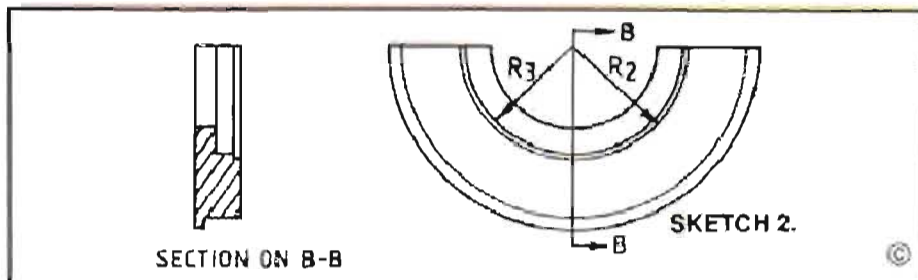
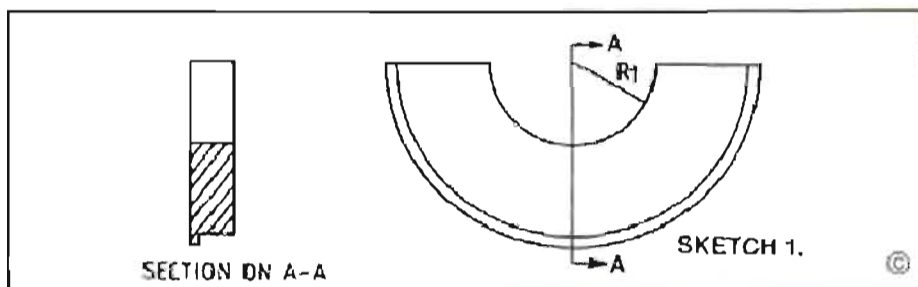
The February/March issue of Model Engineers' Workshop contained a letter from Mr I Johnson seeking information on the metalling of bearings. (Letter at Page 9 refers).

I started my engineering career in 1946 in the motor repair trade and as part of my training, was required to operate a con-rods and machine to size to fit the crank pins. Obviously in those days, most con-rods were 'metalled direct', i.e., the white metal was cast directly into the steel con rods. There were variations including brass shells which were fitted to light alloy rods and, of course, the then new design of rod which carried the thin wall steel, white metalling, bearings. However, no matter the design of con rod bearing, the method of re-metalling employed was the same and was as follows (although some of the names and temperatures have been lost in the mists of time).

The re-metalling plant was a small affair comprising two cast iron pots, approximately 6in. dia. and 8in. deep in one of which "old" white metal was melted whilst "new" white metal was contained in the other. Heating was by use of town gas. Very little control was exercised over the "old" metal since it was only used to melt out the original metal from the rod bearing and as an aid in tinning the rod surface prior to re-casting. The "new" metal pot was temperature controlled (the control temperature has long since been forgotten but could be established either from the manufacturer or by finding the melting point by trial and error).

Mr Johnson mentions "bearing shells" so I will attempt to recall the process specific to shells be they brass or steel.

The first task was always to warm the shells with a torch since to dip a bearing



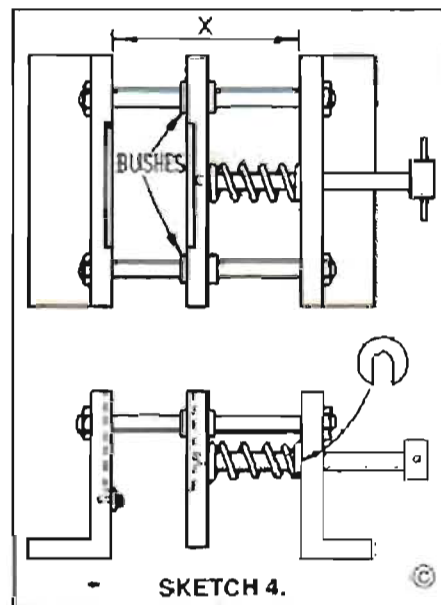
directly into the molten "old" metal would invite an explosion.

The next task was to "paint" the back of the bearing with an "emulsion type paint mixture" to prevent the adhesion of the new metal to the back of the bearing where it would prevent the seating of the bearing in the rod and necessitate the removal of the metal from the back of the bearing by file and/or emery cloth thus removing metal and impairing the pinch of the bearings in the rod. (This point was removed by wire brush after metalling).

The next step was to remove the old metal from the bearing and to re-tin the bearing surface. This was achieved by first warming the bearing until the old metal started to melt and then dip it into the "old" metal pot where all the old metal would be removed from the bearing. In most instances, the tinning of the surface was reasonable but invariably a re-tinning process was carried out. This consisted of sprinkling a tinning powder onto the hot surface which, in turn, would lift off any foreign matter from the steel (brass) bearing surface leaving a clean, completely tinned, surface ready for casting. Unfortunately I do not recall the name of the powder but it had the same effect as soldering fluid when used to tin a surface and hence I see no reason whilst a soldering fluid should not be used for this task.

Having obtained a good tinned surface, the next task was to cast in the new metal.

Immediately in front of the two pots holding the metal was a jig in which the appropriate sized moulding plates were set. The moulding plates comprised two side plates, which were either flat, for non-thrusted bearings, or recessed for thrusted bearings (see sketches 1 & 2). These plates were semi-circular in shape (side elevation) and were recessed at the equator with a semi-circular cut-out into



which fitted a semi-circular core which in turn, carried a funnel into which the molten metal was poured and which acted as a header (see sketch 3). All plates and core were made from cast iron with the side plates being held in position by simple tongues and clips, the core held in position by its own weight and the whole, including the bearing, being held in the correct position location in a simple spring-loaded jig (see sketch 4).

One very important thing to remember is the necessity of heating all the moulding plates, core and jig before introducing molten metal. It was for this reason that all the moulding plates and cores were stored adjacent to the metal pots, thus retaining them at the same temperature as the molten metal.

The remaining task was to cast the new

bearing and this was achieved simply by taking the molten metal, by use of a ladle, from the "new" metal pot and pouring it into the header recess in the core. It was essentially to fill this recess to the top to provide the additional metal to fill in behind the cooling metal thus preventing the formation of blow-holes. It is essential to have the moulding plates and bearings hot enough otherwise the new metal will not run round the bearing but will solidify part way.

Having allowed the metal to solidify and the bearing to cool, it was removed from the jig and the excess metal at the equator of the bearing was carefully removed by use of various grades of files, the back surface of the bearing cleaned by wire brush and the re-machined bearings fitted to the con rod for machining (details of which could be provided).

I see no reason why this task cannot be carried out in a small workshop since there is no sophistication in the equipment required. The side moulding plates can be machined as a complete diameter in a lathe and then sawn in half. The core can be similarly machined and can remain as a complete diameter except that a recess must be machined into it to form the header. I see no reason why mild steel cannot be used for the plates and core except that they will require "painting" to prevent white metal adhesion. The jig itself can be varied to suit any workshop equipment and, indeed, can be made from pieces of scrap metal plus an old valve springs or similar. Good luck!

Technical details

1) Radius **R1** at **Sketch 1** is the size of the finished bearing less $\frac{1}{16}$ in. to allow for sufficient metal to be cast in so that a good, blow-hole free, bearing can be machined.
2) Radius **R2** at **Sketch 2** is the OD of the bearing shell (plus say 0.002) to allow the steel bearing shell to sit in the recess.
3) Radius **R3** at **Sketch 2** is the size of the ID of the bearing shell.

4) The radius of the core at **Sketch 3** is **R1** less 0.002in. to allow the core to sit in the moulding plates.

5) **Dimension X** at **Sketch 4** is an open dimension since the jig can be adjusted to suit the width of the bearing shell by inserting spacers of the appropriate thickness, as shown, to give the required light grip at the bearing.

6) The recesses in the left hand "fixed" angle plate and the sliding centre plate are of a size to accept the OD of the moulding plates. The plates are gripped into these recesses by setscrew and washer as shown. (Two set screws per side is adequate).

Note: The recesses in the "fixed" and sliding plates need not be a complete semi-circle - only of sufficient depth to hold the moulding plates.

7) The bushes should have adequate clearance to allow free movement of the sliding plate when the jig is at operating temperature.

8) Obviously the jig is easier to operate if it is bolted to a base plate.

9) To load the jig:

- clamp the appropriate moulding plates into the "fixed" and sliding plates.
- insert spacers to give the correct degree of grip on the bearing shell.
- insert the bearing shell (obviously turned) by pulling the sliding plate

sideways using the handle (it will be hot!) and then allowing it to grip the bearing shell under spring force.

d) lay moulding core across moulding plates ensuring the entry hole is over the centre of the bearing shell.

e) pour in molten white metal and allow to set. The core is removed at this stage by a sharp tap in the horizontal direction.

f) remove bearing shell and prepare for machining.

Please remember that the jig and all moulding plates and core must be at working temperature before pouring the metal.

Spanner collection

Mr G. Siddall of Halifax shows us a couple of odd adjustable spanners

I congratulate you on your publication *Model Engineers' Workshop*, which I find very readable, with a well balanced format,



and I hope that this magazine goes from strength to strength.

Not many people are aware that the dodge of using a small coin to make an oversize spanner fit a nut (not a good idea - Ed) was commercially exploited at one time. In the photograph, ten slips can be swung to one side to make the spanner fit a suitable nut. The photograph shows 2 from a set of 31 have in a collection of approximately 20 differing adjustable spanners.

A light in the darkness

A reader (details withheld on request) comments on a letter in *Scribe a Line* issue 9 regarding attracting recruits.

B A Martin is right. The future is frighteningly bleak. (Even, environmentally the "throw away" age cannot be sustained but there will be no one who can "make and mend" and so recycle what we have got).

I have found one delightfully bright patch though at "Adult Education" establishments in colleges. I can reach 3 in a 25 miles radius. The courses are often called "Model Engineers" but the one I go to has about 4% modelers and the rest

QUICK TIP

Cut a piece from the side of a discarded white plastic bottle, punch a hole through one edge and hang it by the lutho. The white surface is excellent when setting up jobs it enables you to gauge movement to a nicety.

make tools or machine parts for their home machines. Cost varies but is very cheap at £15.00 to £40.00 per 10 x 3 hour evenings. This often includes some materials.

If you have not got one in your county I suggest trying.

1) advertise to form a group of say 15 people and

2) invade appropriate parts of the local education establishments, point out how they can make some money from a room full of machinery which is otherwise standing idle.

Kerry lathes

Mr E Ellis of Dursley has an elderly Kerry lathe in need of some refurbishment, can any one offer some advice.

I am the owner of a Kerry lathe 5 1/2in. x 23in. An excellent machine, but one that needs its bed re-grinding quite badly. As I managed to pick the machine up some time ago for a good price, I obviously don't wish to spend too much money on it.

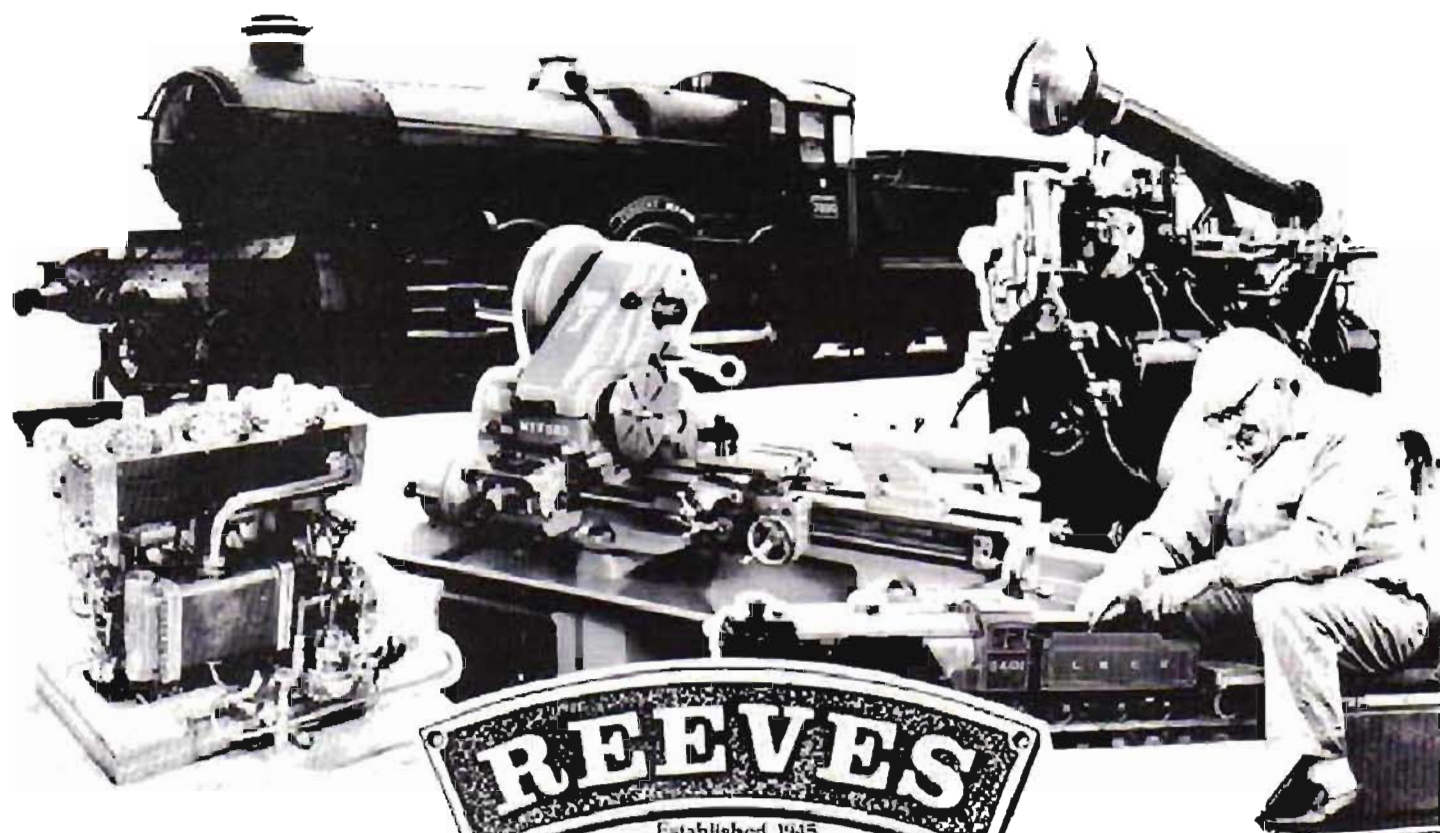
Could anyone let me know where there are companies that could do this work, preferably close to me. Also whether anyone offers a do it at home service.

Grayson Lathes

Mr Bennett of Brownhills requests help with his Grayson lathe.

I am writing to see if any of your readers can help me. I have acquired an old Grayson 3 1/2in. lathe which is pretty much dilapidated the pulleys are available on the lathe spindle, but no other drive components are available. There is a place for the change gears, but no gears.

Can anyone tell me if the company still exists or is there a supplier of spares. Also provide me with details, drawing or photographs, as to how the drive mechanism should be arranged.



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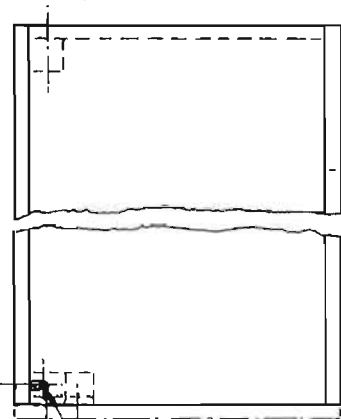
MACHINE COVER



THIRD ANGLE

MACHINE COVER

MATL: $\frac{1}{4}$ PLYWOOD



2 BA STUD & WING NUT
SLOT IN COVER EACH SIDE

M/C BASE

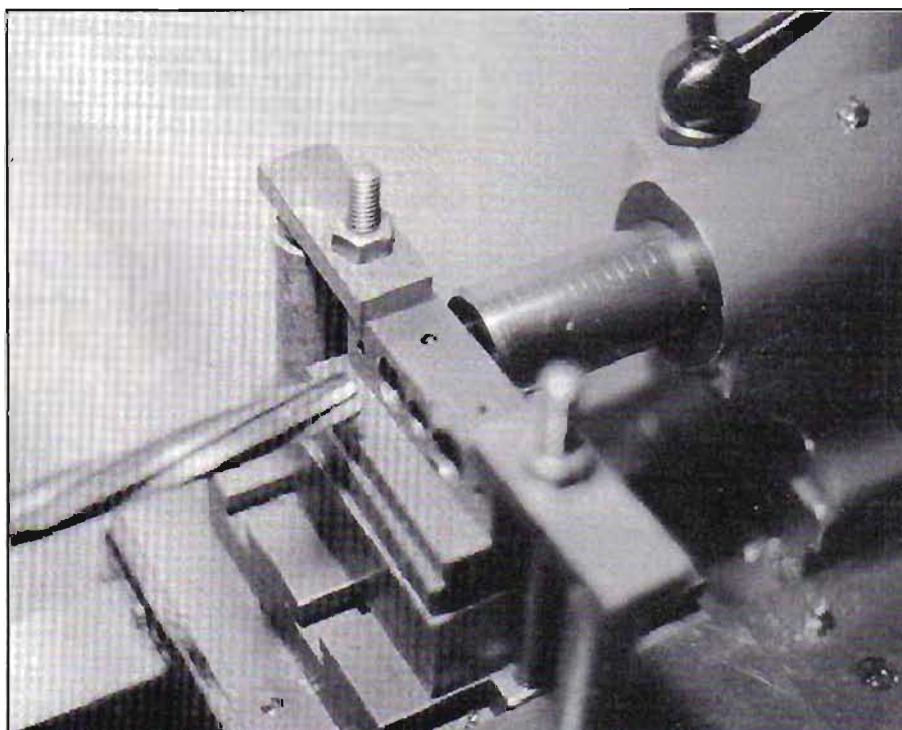
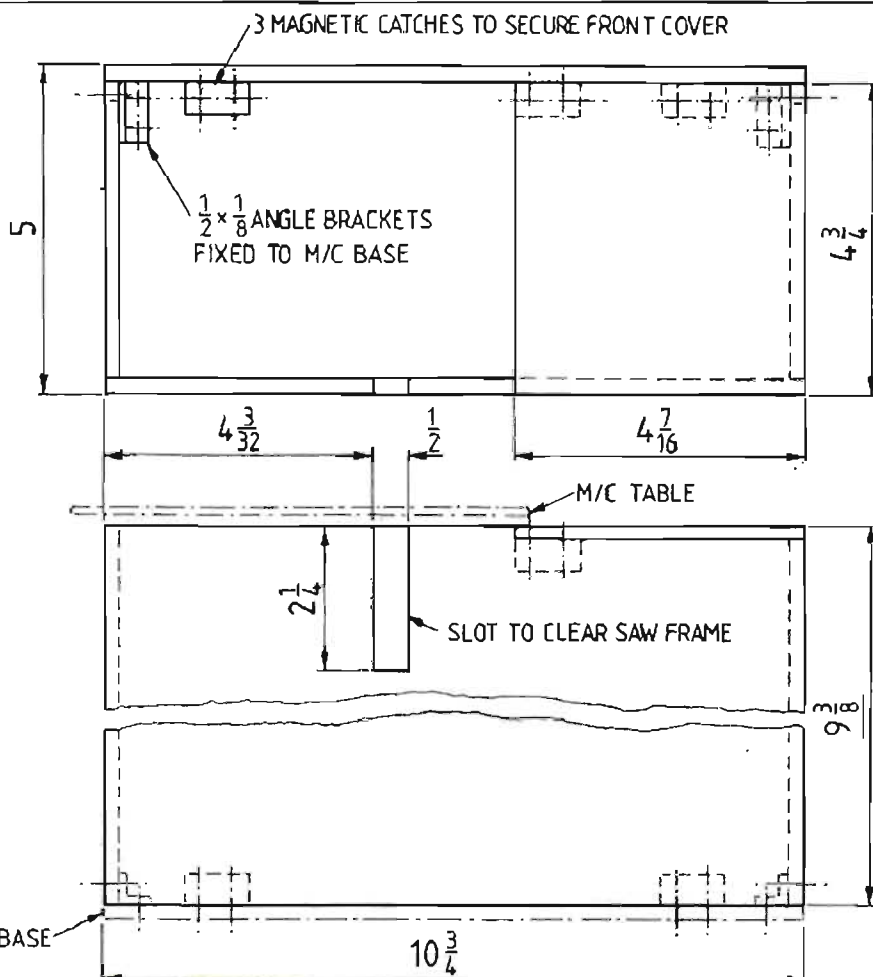


Photo 3: Using the tailstock barrel as a pusher whilst reaming the holes in the support block. The same method was used when drilling the holes.

square piece of B.M.S. was now marked off and drilled through No. 13 drill. The three pieces were bolted together with a 2BA bolt and then silver-soldered together. The ballrace recesses were then machined using the 4 jaw chuck.

Item 8 fits on the crank between the ballraces to prevent them from being too highly end loaded, although this is unlikely in this application, so you could leave it out as I did. If it is fitted it must be exactly the same length as the distance between the inner faces of the ballrace recesses.

QUICK TIP

Colour-code imperial, metric, letter and number drills by grinding a bevel on the non-business end and dipping the roughened surface in paint of the chosen colour-code. One or two were accidentally dropped into the paint, the flutes themselves thus becoming colour coded and recognisable, even when in use.

W Brian Taylor

LING MACHINE

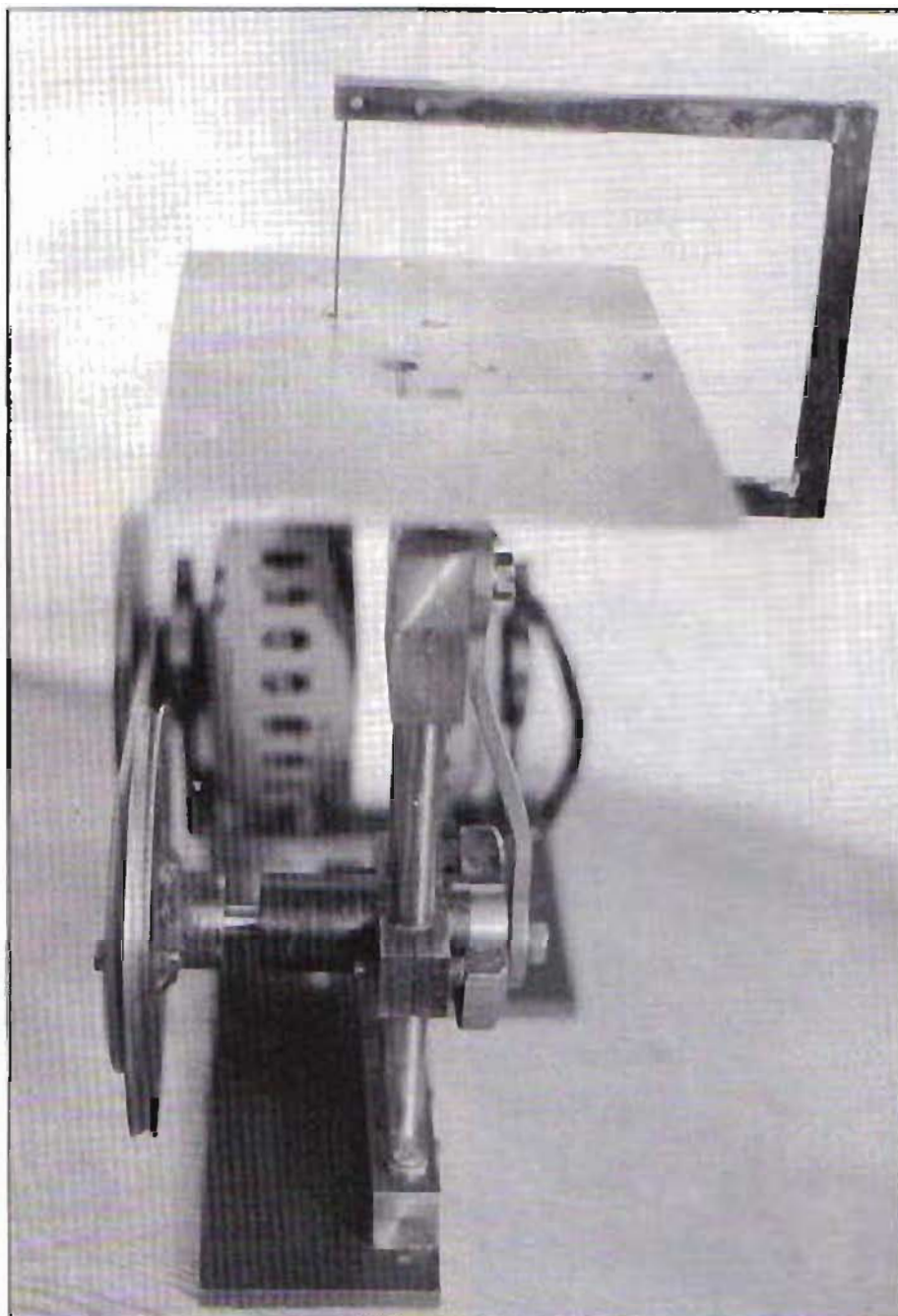


Photo 4: A close-up view of the crankshaft bearing housing

Photo 5: A demonstration cut on a piece of brass; note the various holes in the table for other functions

QUICK TIP

I have just got back into model making after many years and find the M.F.W. a godsend! Having said that, here is a very quick tip. I was sorting out the drills that had been floating about the house, on a bench my wife had used for flower arranging and stuck the drills into some Oasis. Within seconds I found that I had a temporary drill stand! This would, stuck somewhere convenient, the top of the gear box for instance, stop the loss of bits, various drill centre bits, scriber etc., wandering about in the swarf.

Peter Wilson

(Oasis is a flower arranger's base and is obtainable from good florists and garden centres - Ed)

The balance weight, item 16, was made by cutting a $\frac{1}{16}$ in. thick slice of $2\frac{1}{2}$ in. dia. B.M.S., boring out to $1\frac{1}{16}$ in. dia. or a sliding fit on the crankdisc. It was then cut to shape on the bandsaw and secured in place by a 2BA grub screw.

Item 4, the brass tool block, I made by silver soldering together two pieces of $\frac{1}{16}$ in. thick brass plate. On the drawings I have called for the block to be $\frac{1}{16}$ in. thick to give a bit more meat for drilling and tapping. I mostly use needle files with the tangs ground and stoned to $\frac{1}{16}$ in. dia. to slide in the upper brass guide, **photo 6**, item 13. Larger files such as $6 \times \frac{1}{4} \times \frac{1}{16}$ in. precision files can be used without an upper guide.

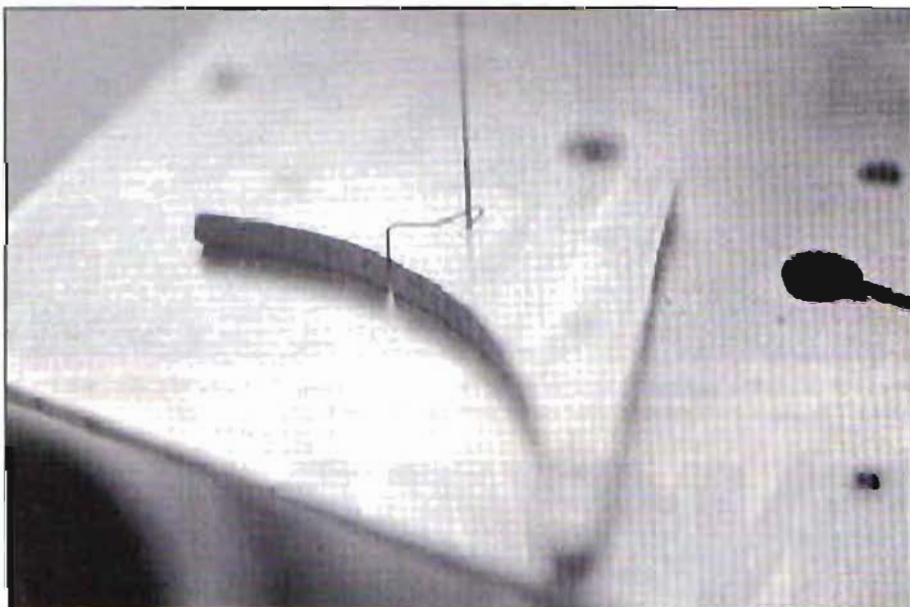
The fretsaw frame is built up from $\frac{1}{4} \times \frac{1}{16}$ in. B.M.S., silver soldered together. It is fixed to the tool block by 2 x 4BA socket head screws. The saw blade clamps are also $\frac{1}{4} \times \frac{1}{16}$ in. B.M.S. tightened by a 4BA socket head screw. Each clamp has a $\frac{1}{16}$ in. locating pin to keep it in position when slackened off. The size of frame shown covers most of my needs, but I had to make a 9in. frame when I made a John Wilding large wheel skeleton clock. I did in fact make two of these clocks, cutting the two large wheels together and this entailed fretsawing some 140 in. of $\frac{1}{16}$ in. thick brass and the machine took it in its stride. **Photo 5** shows a piece of brass being cut.

I have not shown the various holes in the worktable for saw blades and files as I think these are best marked off to suit the job.

The motor I use is $\frac{1}{8}$ th H.P. 0.29 amps at 1400 R.P.M. is very quiet and makes for a very smooth running machine. The driving belt is Whiston's polyurethane $\frac{1}{16}$ in. round.

The last items are the guards and these are made from $\frac{1}{16}$ in. plywood glued and pinned together. The main guard, consisting of two ends, rear panel and top piece over the motor, slides on from the rear and is held by two 2 BA wing nuts at the bottom front of the two sides. The front guard is a single piece of $\frac{1}{16}$ in. plywood, magnetic catches holding it in position. This gives instant access for replacing broken fret saw blades.

I find I haven't mentioned jig saw blades but these can be fitted to the tool block to suit and I must admit to rarely using one. The three alternatives, jig saw, fret saw and needle file can be seen in **photo 7**.



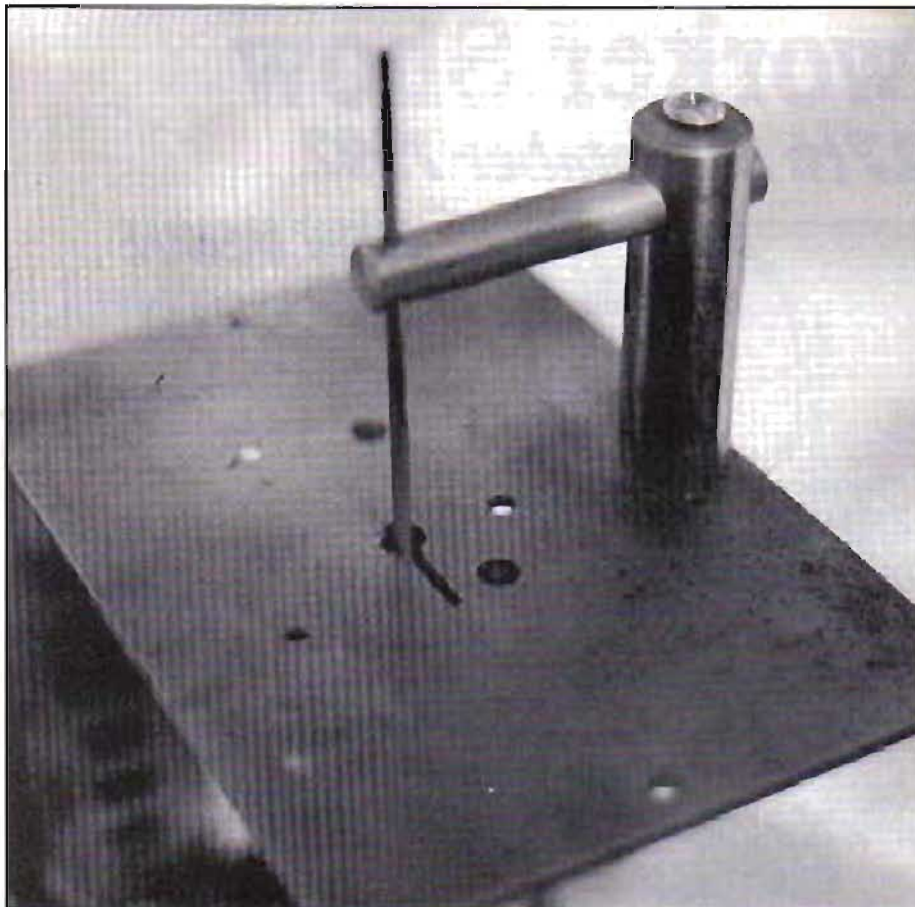


Photo 6: The conversion to a filing machine; the file cuts on the down stroke

The front crankshaft ballrace requires protection from falling metal and wood dust. I fitted a piece of 0.020in. brass round the bearing housing held on with a pipe clip, the brass extending over the pulley boss.

An added refinement is a means of removing metal or wood dust from the working area where it always obscures the scribed line. A small bellows could be

worked off the con rod but I haven't managed to do anything about it yet. I use a 12in. length of $\frac{1}{8}$ in. dia. cane held by the teeth like a long cigarette holder to blow the dust away and it is also good exercise for the lungs!

I think this covers all the salient points and so I will now let you get on with making your version.

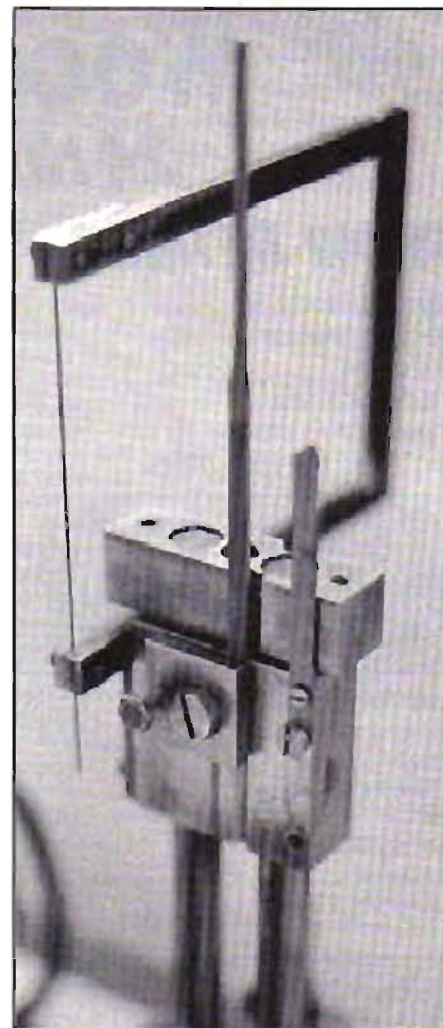


Photo 7: The three optional uses for the machine, seen in this shot with all set up in the tool block. Fretsaw, file and jigsaw are arranged left to right

MORE MUSEUMS OF INTEREST

Following the details in the last issue regarding museums of special interest to readers of this magazine, we offer this additional short list of museums suggested by readers. The information given is limited, but hopefully will be of use.

Halifax Peace Hall, Halifax.

Industrial museum: Steam engines, Textile machinery, Machine tools.

Dinorwic Slate Quarry, Maintenance Workshop, Llanberis.
Workshop in its original form, very

large number of machine tools driven from long lengths of line shafting. Highly recommended.

Museum of the History of Science, Broad Street, Oxford.

Scientific instruments, clocks, photographic, etc.

Whipple Museum of the History of Science, Free School Lane, Cambridge. 0223 334540.

Scientific instruments.

Musée National Des Techniques, 270 Rue Saint Martin, Paris.

Antique machinery is fascinating, it seems to you as well as to us. The listing below is sent in by readers who recommend them as well worth a visit.

Nearest Metro station: Arts et Métiers.
Large display of equipment used in the making of scientific instruments and also Machine tools. Closed Mondays.

Penrith Steam Museum, Castlegate, Penrith.

Machine tool workshops.
Also many Railway restoration workshops including:
Mid Hants, workshops at Ropley.
North Norfolk, workshops at Weybourne.
Llangollen, workshops at Llangollen.
Camforth Steam Centre
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North Yorks, Grosmont
Ffestiniog, Boston Lodge, Portmadoc.

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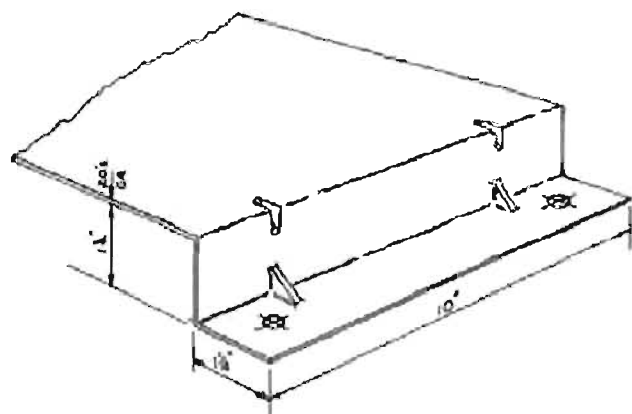
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The need to produce stiffener ribs on the folds of a sheet metal cover led to the construction of a general purpose workshop press.

Fig. 1.

©

JACK THE RIBBER

Unacceptably wobbly fold lines of "Z" section sheet metalwork led to ideas about how best to form a rib-effect across the bends (Fig. 1).

Exploratory trials using a pair of home-brewed form tools in a heavy duty bench vice (Fig. 2), showed promise but clearly indicated that pressing even thin sheet steel to a rib section called for a deep-throated thingumajig, able to produce a squeeze far in excess of that produced by a bench vice.

In what may sound to be a contradiction in terms, we decided the only way to make progress would be to "jack-it-in"; apply the squeeze with an hydraulic jack.

A foray into the scrapyard

A browse round our local scrapyard revealed a scruffy-looking cross between a shaving mug and an old boot. Relieved of its grime it proved to be a fully functional slipper type hydraulic jack stamped:

S.W.L 3 Tons

From above, its dumpy body occupied a 8 x 3 1/2 in. footprint; from the side, its pump and release valve were accessed from the low toe-end, behind which its silhouette rose to form a squat cylinder centred about 1 1/2 in. short of the heel. The telescopic ram had around 5 1/2 in. of movement, increasing

QUICK TIP

Markings on drill shanks are more easily read if rubbed either with a black wax crayon when the shank has a bright finish or with white chalk when the finish is unpolished and dark.

W Brian Taylor

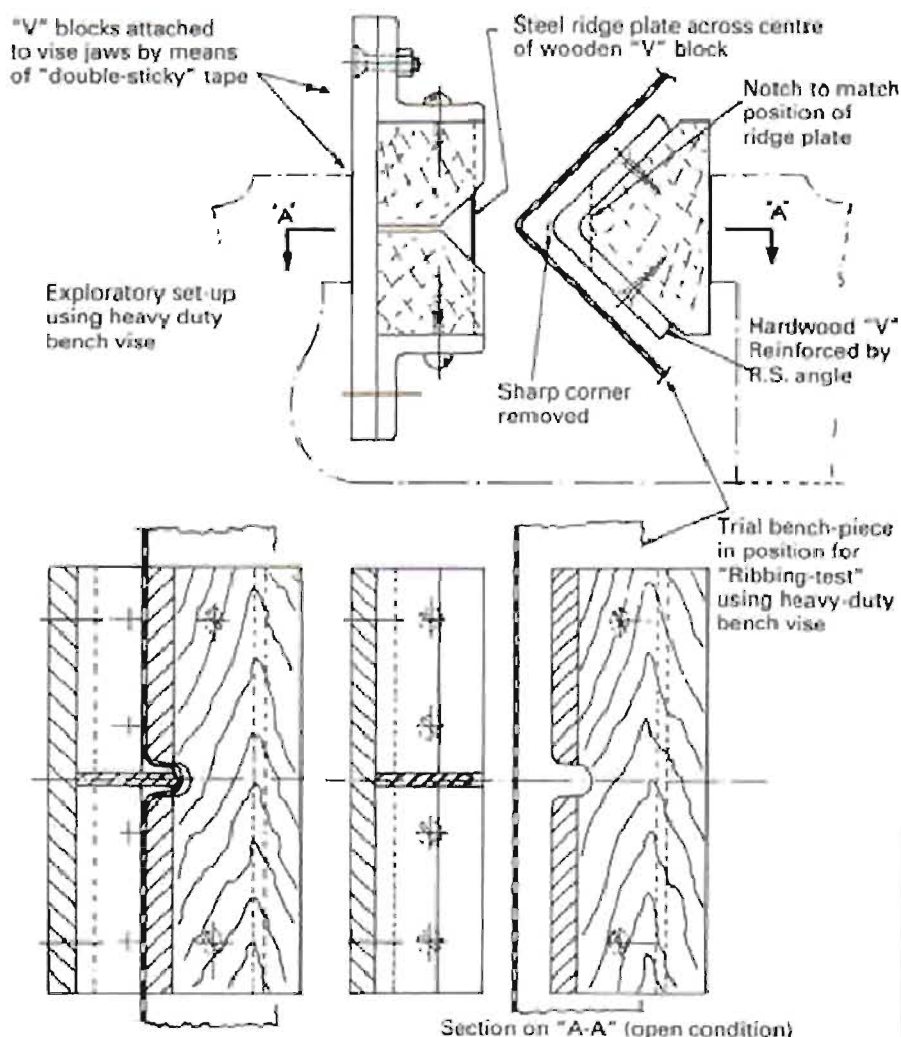
In this interesting and amusing article by W. Brian Taylor, he gives an account of designing and making a useful hydraulic press. The article includes drawings in his own distinctive style.

the height from about 4 1/2 in. when closed to roughly 10 in. when fully extended, as shown in Fig. 3.

A thick coat of think-about hatched nebulous doodles for a 3 ton, hand operated hydraulic "picture-frame" press, the final design dependent on our luck with materials during a diligent scrapyard search.

We envisaged identical top and bottom beams, secured one above the other at the jack's fully extended height by end-columns; the jack thus able to sit anywhere between the columns with about 5 in. of usable daylight over the ram when retracted – or to push against the beams with a force in the region of 3 tons when loaded.

At the yard, pot-luck produced four 24 in. lengths of 5 x 2 1/2 in. channel and four pieces of inch-and-a-bit round stock cut from rear axle half-shafts which, along with a goodie-bag of various RS off-cuts, allowed us to



Theoretical section on A-A with vise jaws in closed condition

Fig. 2.

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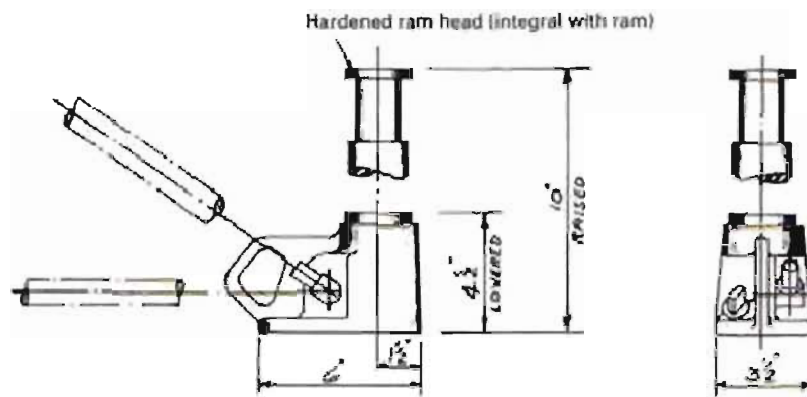


Fig. 3
Relieved of its gunge the old boot became a fully functional 3 ton hydraulic jack.

©

press-on as they say; the outcome depicted in **Fig. 4**.

We made identical-twin beams in accordance with **Fig. 5**, both assembled from a pair of back to back channels, with inch square spacer tubes forming a lengthwise groove. In addition to four bolt holes in the webs, each channel had four holes bored to clear the columns which, being full height, passed through all beam flanges. **Fig. 6** portrays details of four identical columns, each reduced at the ends and threaded for 1 in. BSW nuts and locknuts.

Please note that with suitable adjustments to column and spacer dimensions, construction details are equally appropriate for use with tall "upright-style" hydraulic bottle-jacks.

Tubing suitable for the beam-spacer sleeves? We found it lying on a scrap dump of thin-wall HGV exhaust pipes!

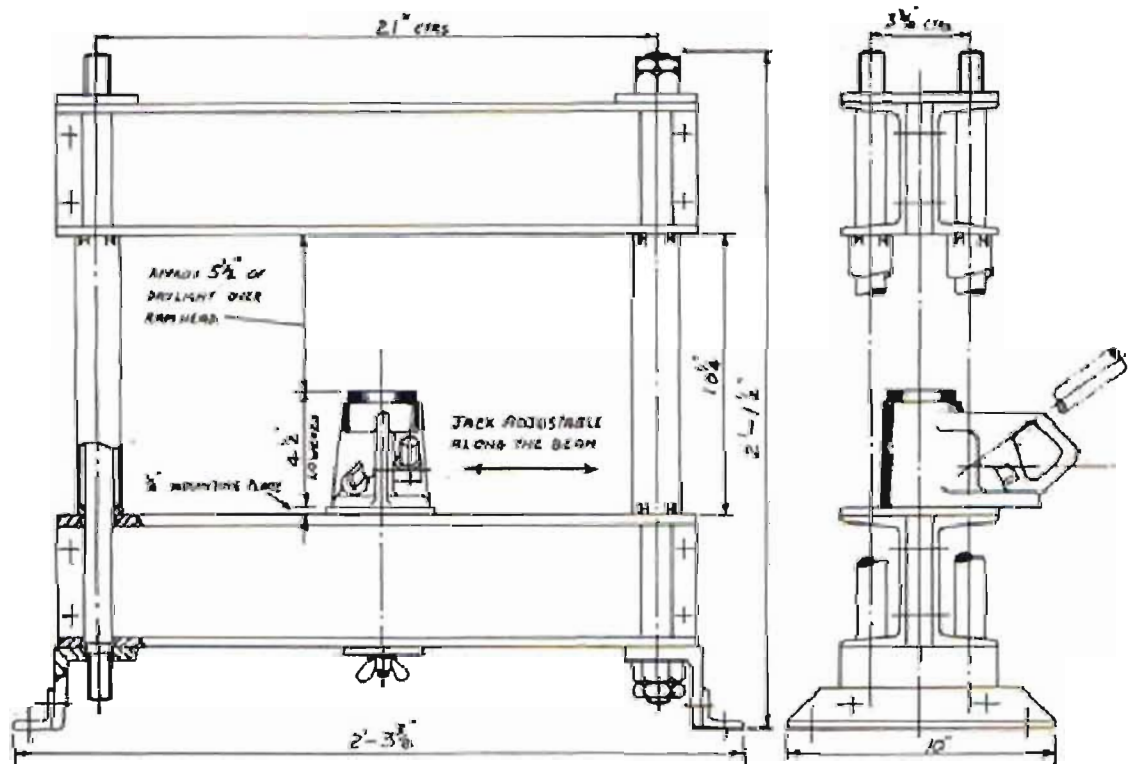
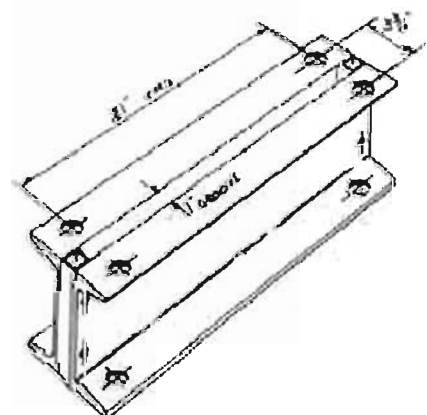
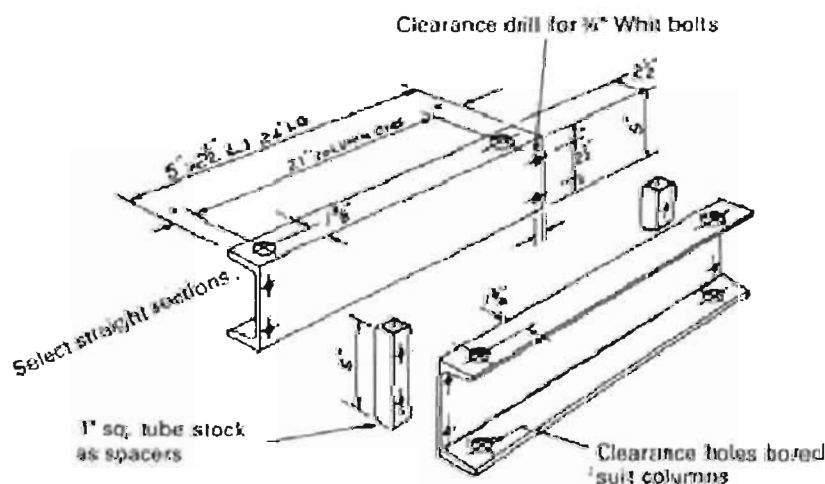


Fig. 4 General arrangement of 3 ton hydraulic picture frame press.

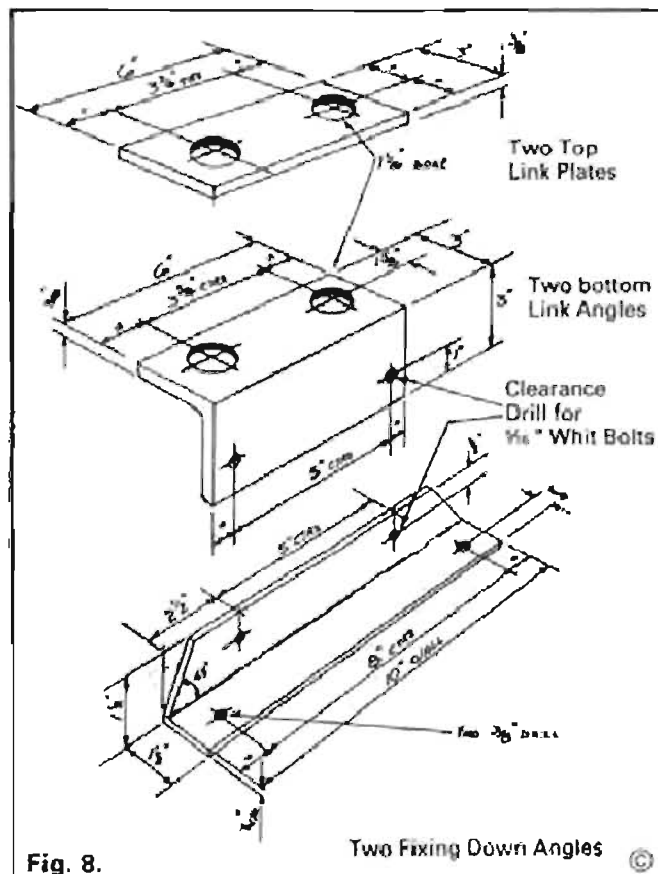
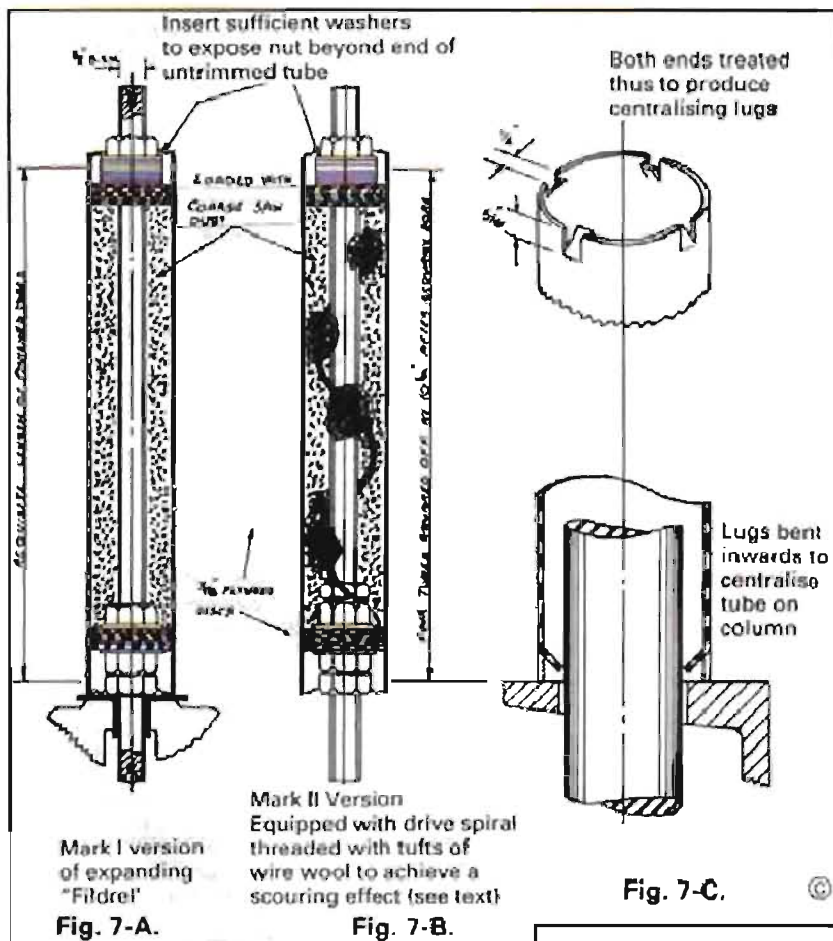
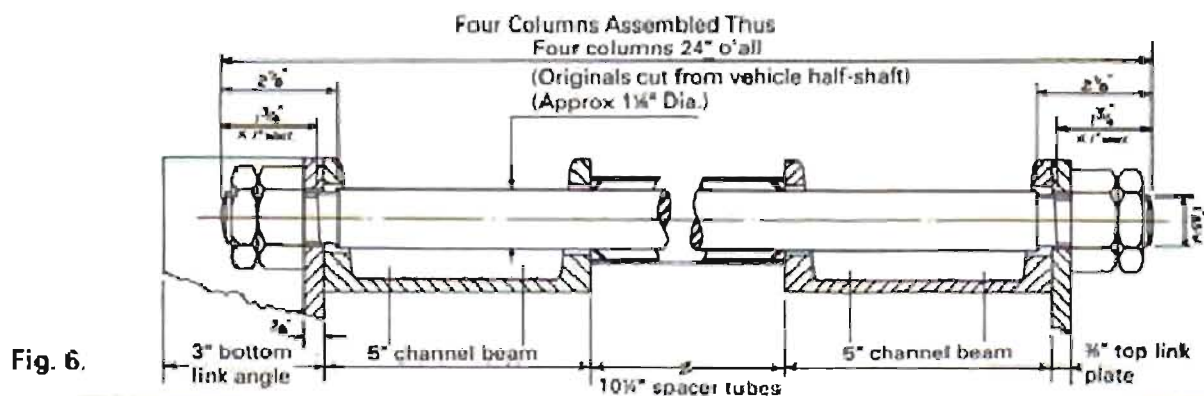
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Assemble two beams thus

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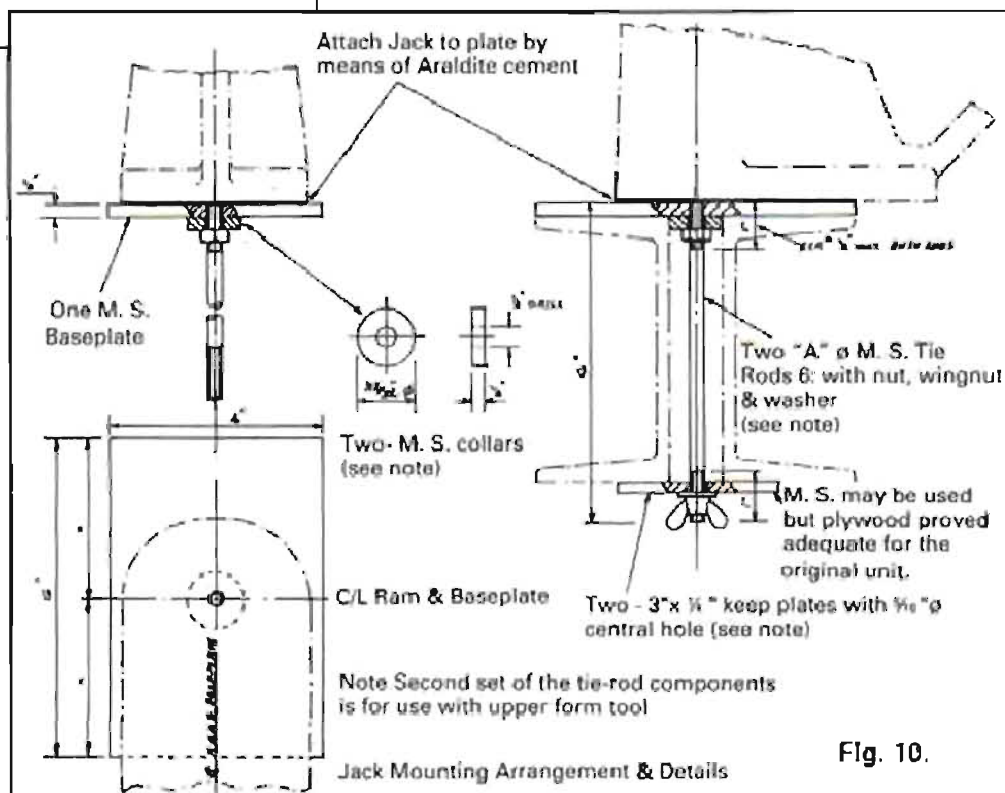
Fig. 5.



Gripping thin wall tubing

Brainstorming gave rise to a "fildrel": an unconventional yet simple and highly effective means of gripping thin-wall tubes in order to gain access for squaring the ends, emerying the outside's rusty patina and trimming to a common length.

Two 3/16 inch thick plywood discs were bored 1/2 inch, their concentric O/D making a reasonably close fit within the tubes. A handy length of 1/2 inch BSW screwed rod, centre drilled both ends, was set vertically in a vice between soft-jaws as shown in Fig. 7A. Two nuts, locked on the rod just clear of the vice, were followed in sequence by a washer, a plywood disc, a second washer and nut to nip them all in place. They were followed by a tube which, centred by the disc, rested on the jaws. In a manner similar to potting a plant, the tube was near-filled with tightly-packed coarse sawdust, followed by the second disc, a number of washers and a nut. A few turns with the spanner and Hey presto! the tube



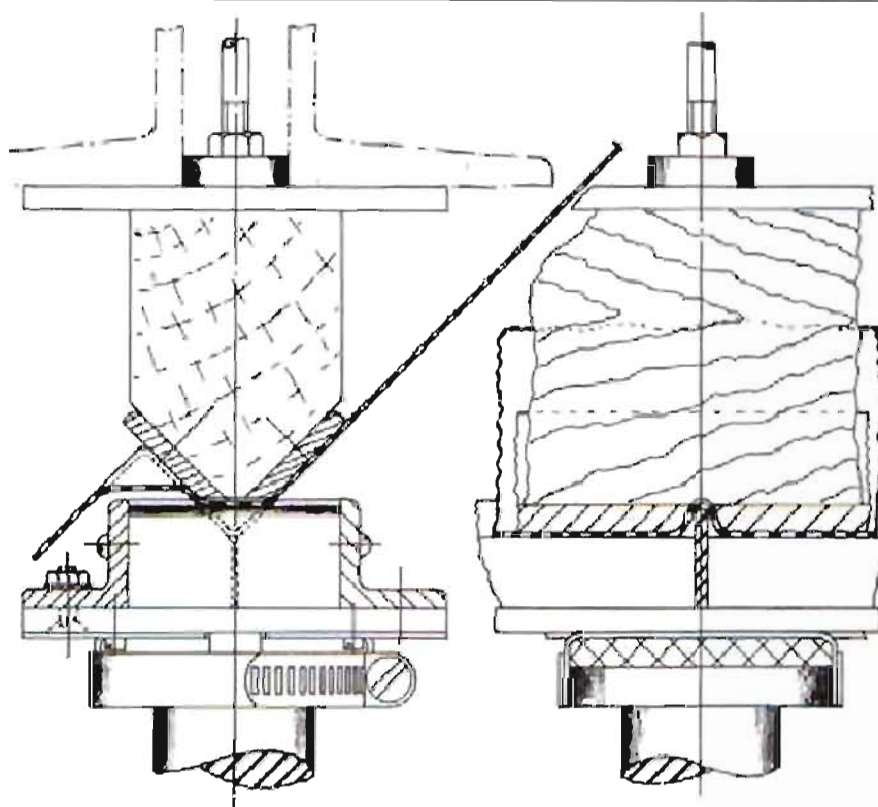


Fig. 10. Part sections to show rib formation on folded "Z" bend

and its filling became a solid bar with concentrically projecting ends.

Shaken free of loose dust and transferred to the lathe (newspaper covering the bed!), it performed as intended, the first tube polished and square to length in no time. Diesel-soot inside our four tubes, although messy, was of no real consequence but it led to a bonus. It suggested itself when (with power switched off), we gradually slackened the clamping nut, reaching a stage where the filling relaxed its tight hold on the tube. Hence we were readily able to grasp it and apply a combined axial and rotary motion.

We had visions of the coarse sawdust scouring away the tube's sooty lining but we should have known better; we found our efforts had merely rotated the tube and its filling on the rod.

We got a grip on things by producing a Mark II fildrel as shown in Fig. 7B. The springy wire spiral, strung with wirewool tufts, anchored the filling to the rod. By repeating the combined rotary and axial motion we scoured the bore free of soot, but it called for care to avoid exposing the discs and the inevitable dumping of sawdust on the lathe's oily bed – not the end of the world but a tedious clean-up chore to be avoided – hence the bed's newspaper covering, just in case.

From experience gained, the second and subsequent tubes were scoured as a first operation before facing the ends, so removing interior grime from a length in excess of the final overall dimension.

It is worth noting that we later made use of expanding fildrels in various sizes when rigid PVC thin wall plastic tube or flimsy "tin-can" gauge metal tube had to be gripped and rotated in a lathe.

Fildrels also allowed operations akin to metal spinning; sawdust acting as a flexible

semi-rigid "form" when grooves had to be impressed round thin metal tubes. When called upon to produce a "pearl" effect on the inside of clear Perspex tube, we substituted sand in place of sawdust.

Back to the press

Returning to the press job; experience taught us that our resident gremlins would take great delight in pushing thin-wall sloppy-fit spacer tubes into eye-jarring positions, anywhere but concentric with column centres. As illustrated by Fig. 7C, we thwarted enemy action by forming four inward facing lugs at the tube ends, each lug bent to a reasonably close fit on the columns.

Fig. 8 shows two column-top links, formed from 3 x 1/8 in. MS flat and two bottom links from 3 x 3/4 in. angle.

All had 1 1/8 in. bored holes; other holes in the angle allowing two lengths of 1/2 x 1 1/2 in. equal angle to be bolted in place to form feet, while other holes provided a means of fixing the unit to a stable bench; an essential safety precaution to prevent beefy pumping action upsetting the appletart.

Work on Jack

Fig. 9 illustrates the method by which the jack was mounted on the lower beam. After carefully outlining the position of the jack on the baseplate with a marker pen, the fully assembled plate was nipped finger tight roughly centrally along the lower beam. Checked to ensure surfaces were free of grease and dirt, we bonded the jack to the baseplate with Araldite. By jacking the ram against the upper beam we clamped the joint and avoiding any risk of fixing holes piercing the jack's hydraulics. As working conditions always placed the joint under compression, the adhesive merely prevented the baseplate parting company whenever the jack was repositioned along the beam.

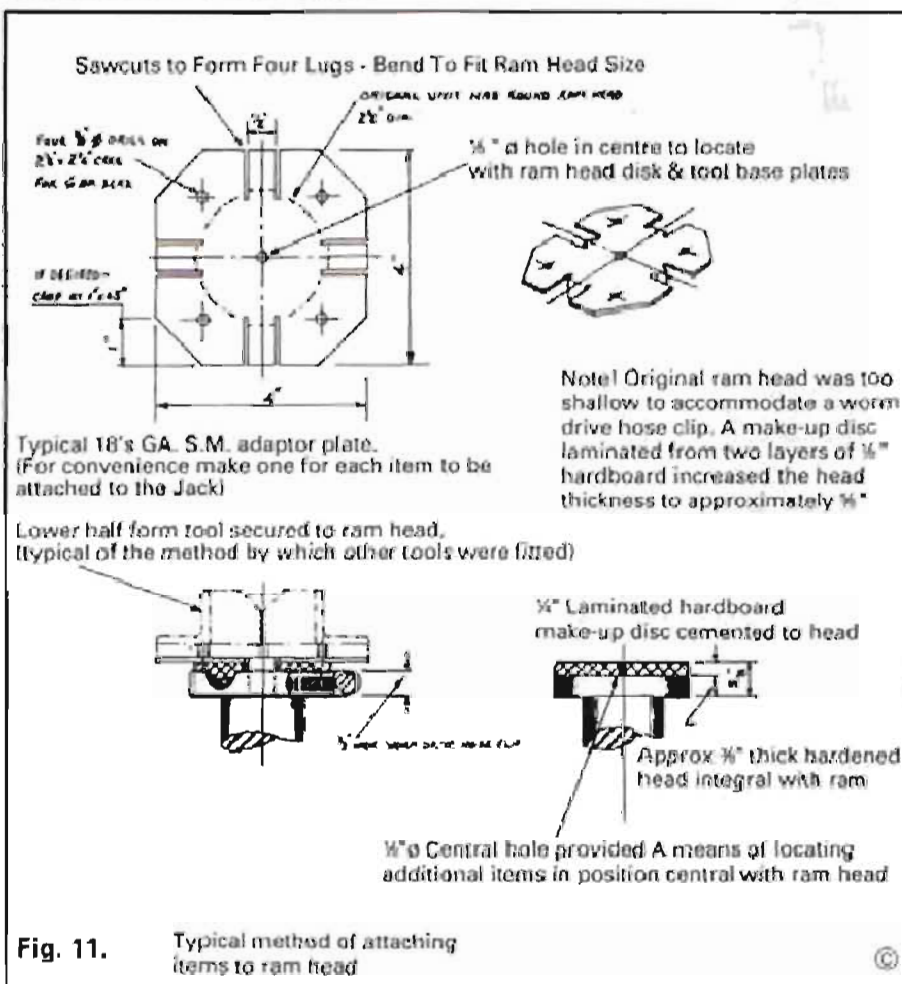
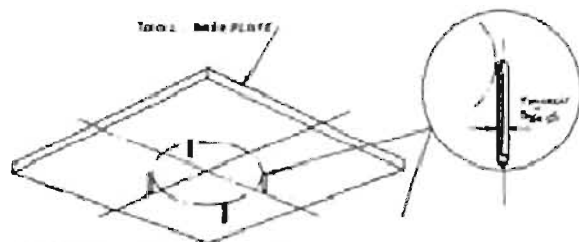
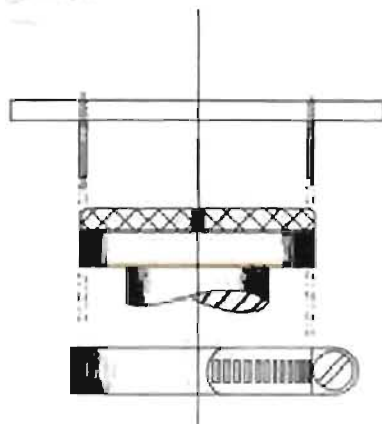


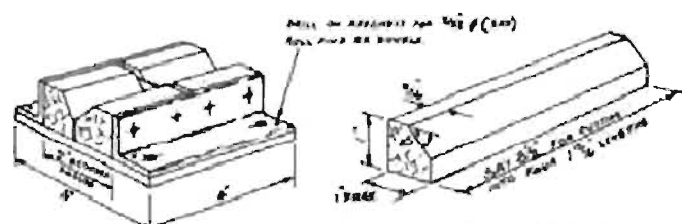
Fig. 11. Typical method of attaching items to ram head



Hollow spring Rollpins driven into base adjacent to outline of head



Alternative method for clamping tools to head
Fig. 12.



Four $\frac{1}{2}$ " Drill & C/Sk Scrs.
Four Drills & Tap 6BA.
Hardwood (Beech) "V" Block Section
Two 1" x 1" R. S. angles
One M. S. Baseplate
Assembly and details of lower half form tool
Fig. 13.
One M. S. ridge plate



Trials and tribulations

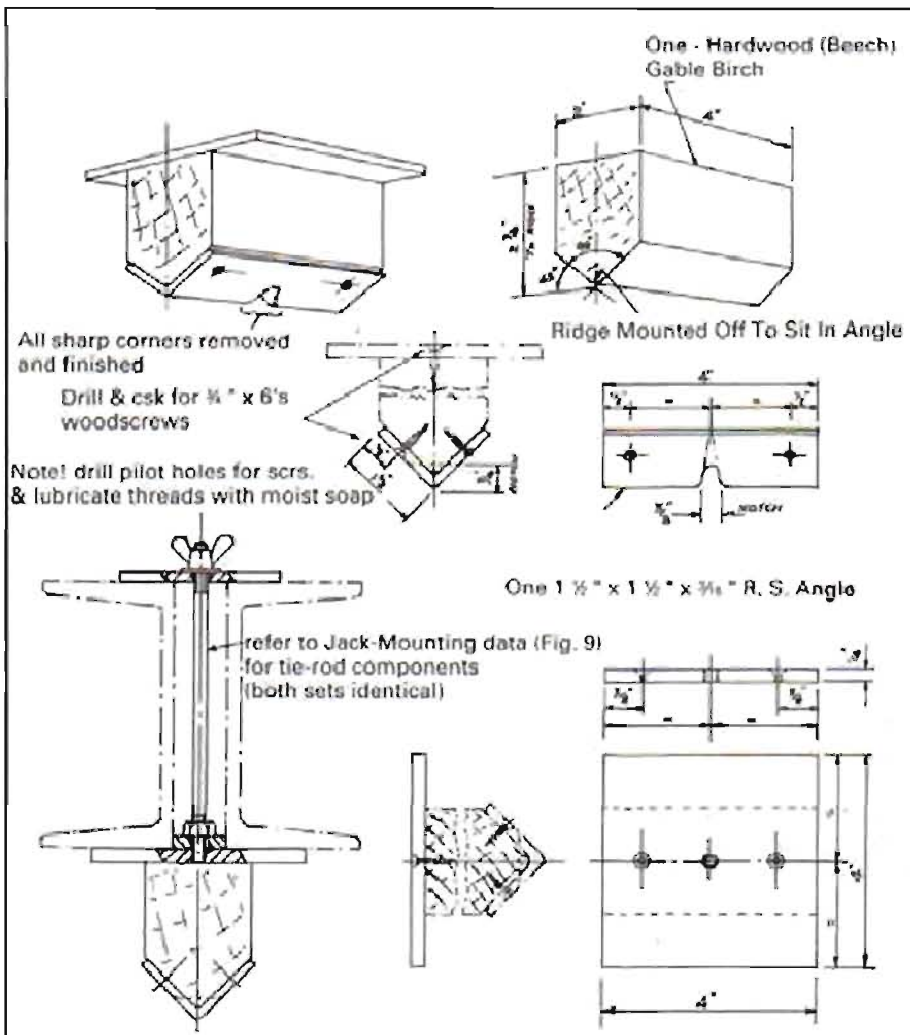
With the aid of our new thingumajig – a 3 ton press – we set out the task of forming fold-line stiffener-ribs on the bend-lines of "Z" section S.M. test pieces. Simplicity being the keynote, we built a purpose-made version of the form-tools as used in the vice for the exploratory trials (Fig. 10).

Screwing anything directly to the ram was ruled out due to the jack's virtually integral head being hardened. Our original tool had an adaptor plate as shown in Fig. 11 (Rollpins did the job in later tools, as depicted in Fig. 12, value engineering thus eliminating the adaptor plate and its screws).

Adaptor plate lugs (or rollpins) provided a means whereby a worm-drive hose-clip clamped a tool to the ramhead. As standard hose-clips are $\frac{1}{4}$ in. wide, it was necessary to add a make-up piece to increase ramhead thickness. Using Araldite and ram pressure, we laminated two thicknesses of hardboard from which we turned a disc to match head diameter. We also took the opportunity to chamfer one edge of the disc and to drill a $\frac{1}{4}$ in. central hole which, should the need arise, could be used for locating ram centre. Again using jack pressure and Araldite we permanently bonded the disc to the ramhead as shown in Fig. 11.

The lower tool (Fig. 13), comprised a baseplate bolted and dowelled to which were two $\frac{1}{4}$ in. by one in. equal angles set 2 in. apart. Four pieces, cut from a length of hardwood (we used beech) and chamfered at 45 deg. as shown, combined to form a 90 deg. "V" block. At the same time they served to position a rounded-top steel ridge plate, located centrally across the "V".

The upper form tool (Fig. 14) comprised a 90 degree "gable-end" beechwood block



Assembly & Details of Upper-Half Form-Tool
One M. S. Backing Plate
Fig. 14.



secured to a baseplate, the working surfaces of the table being reinforced by attaching a length of $1\frac{1}{2} \times \frac{1}{2}$ in. equal angle. A notch cut into the gable at mid-length coincided with the ridge-plate set across the Vee of the lower tool, as shown in Fig. 10.

In addition to the notch's dimensions allowing generous clearance for metal thicknesses, it had tapered sides, all corners well-rounded and polished to a smooth finish with fine "wet-or-dry". A film of grease eased the flow of metal as the rib took shape.

For constructors more at home with metal than timber, there is nothing to prevent the tools from being of all-metal design on the lines depicted in Fig. 15.

In the case of the lower tool, a solid metal "V" block would require lateral plunge milling to receive an inserted ridge-plate. An all metal upper tool may have a narrow tongue, notched as for the wooden design and mounted on a backing plate as shown.

Experiments showed it best to let the tools "find their own position" i.e. the upper tool being free to self-adjust on the beam when closing on the first workpiece; its wingnut then finger tightened with the tools in the closed position.

Home-brewed it may have been, but our **Jack the Ribber** fulfilled all expectations. As is often the case, once the press was available we added a variety of tools and attachments to make full use of its vast capabilities. In fact many jobs could not have been considered, let alone achieved, without the persuasive power of **Jack the Ribber**.

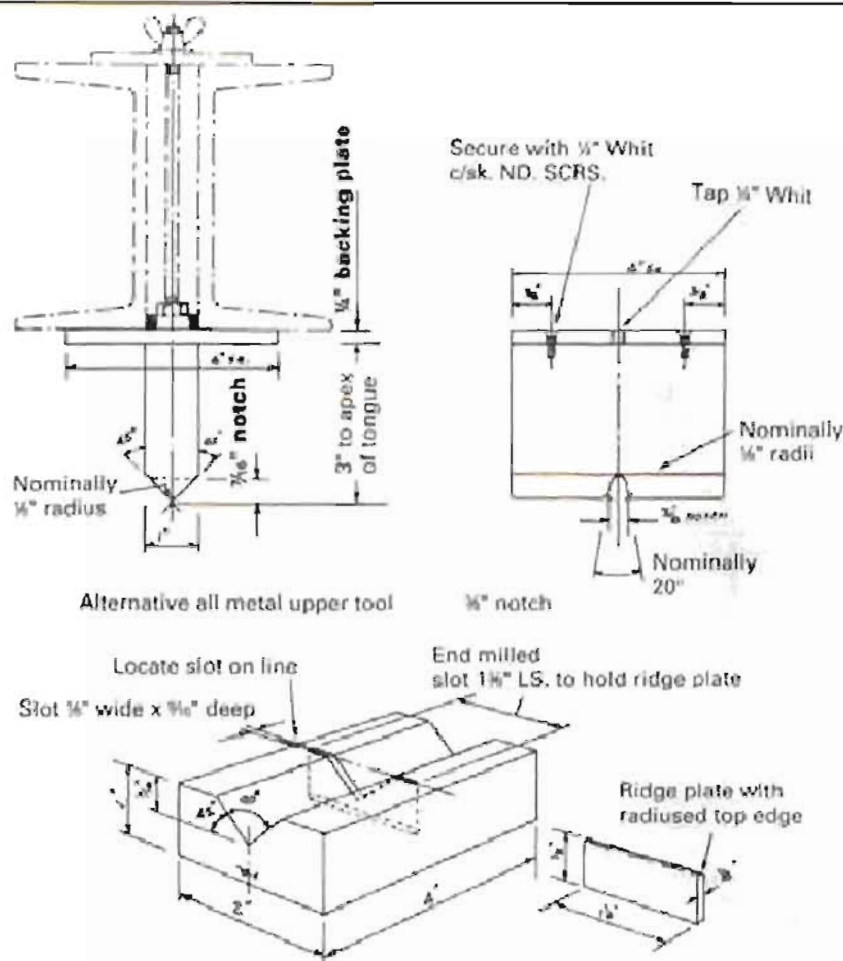


Fig. 15. Alternative all metal lower tool

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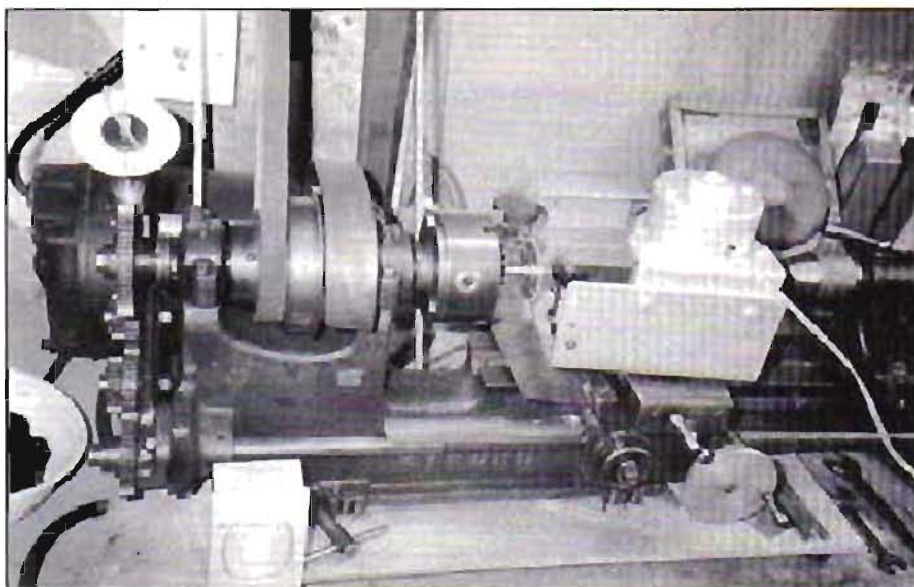
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Mr M LeMarchant has made this excellent little wheel engine largely from scrap. Whilst the same materials will not be available to other readers, we are sure that the principle of the design can be followed by those wishing to make a similar item.

My hobby is the repair and restoration of old and interesting clocks, also making clock and clock-related mechanisms, and it has become obvious that I could do with a means of making gear wheels.

As a pensioner, I cannot justify the purchase of a commercial wheel engine, so I had to think of an alternative and the



A WHEEL ENGINE FROM SCRAP

following is the result. I have an ancient Myford lathe (M.L.1) and this forms the basis of the device.

First I had to have a cutter, so my only purchase was a small fly-cutter from Chronos. The motor to drive it was found in the remains of a ventilation fan among the debris on a derelict tin mine; it was seized but sealed and turned out to be quite a powerful 12-volt AC/DC type. Worked from a mains transformer it has done sterling service.

The frame was sawn from a piece of rusty angle iron I found on the road (off the back of a lorry!) The cutter now mounts on the lathe cross-slide.

The next requirement was a dividing arrangement. With a wheel blank on an arbor in the lathe chuck you can do a limited amount with a change wheel on the back of the mandrel, but this isn't ideal, so I set about a dividing head.

I turned up a worm on the lathe to match the 60-tooth change wheel, using a piece of $\frac{1}{2}$ in. dia. scrap steel rod. This was an interesting exercise to give me a worm wheel of 10 t.p.i. This was mounted on a piece of $\frac{1}{2}$ in. silver steel rod in a stout bracket (ex Morris Minor dynamo



mounting). A wire cross-handle was fitted to the end of the $\frac{1}{2}$ in. rod, a dial made from white painted aluminium was glued to the end of the bracket, a spacer keeps the handle clear of the dial (a bakelite ring from a cupboard door handle) and a brass collar, spring and leather washers inside the bracket take care of end-float.

The bracket now bolts onto a spare change wheel mount on the lathe headstock, so the worm engages the 60T wheel on the mandrel, and we are ready to go. One turn of the worm turns the wheel one tooth, giving me 6 deg. and the dial is easily divided by six, giving me single

degrees, and these subdivided by four for quarter degrees.

This is not a high precision machine as the change wheel is not a rigid fixture on the mandrel, being located by a collar and pin, giving a small amount of backlash, but by being careful always to turn the worm one way only, backed up by a weight on a string wound round the chuck, this is neutralised and results using this device have been quite successful.

To use the divider one divides 360 deg. by the number of teeth required, e.g. 60T = 360 deg. divided by 60 = 6 deg., i.e. one turn of the wheel per tooth. It can be tricky with some wheels, e.g. 32T = 360 deg. divided by 32 = 11 + $\frac{1}{2}$ deg., but it is possible to do this one with a lot of care and concentration. On fine work I lock the headstock for each tooth by tightening a bearing.

The trickiest job I've done with this is a contrate wheel for a carriage clock which is $\frac{1}{2}$ in. diameter with 60 teeth – the gaps between the teeth measured 12 thou, I cut them with a fine slitting saw and finished the teeth by hand, and it was successful!



Postscript

Mr Le Marchant does not detail the type of cutter unit obtained from Chronos Ltd (Tel: 0727 832793) but it would appear to be their 2 inch Cutter Frame part no CF2F and priced at £20.15 (including VAT and postage) in their catalogue number 25. Other types and sizes are available. Ed.



In the last issue, Mr Swallow provided a design for a ball turning attachment. In this he indicated the initial stages in making a ball handle of the type frequently found on machine tools and, in particular, the popular Quorn Tool and Cutter Grinder.

Armchair tuition (for some)

This brief article takes over where the last left off in describing the making of these handles and indicates one possible method of completing the exercise. It is intended as much as armchair tuition for those readers who are inexperienced in the use of lathes, as it is for those who will actually go on to make ball handles for their Quorn or other machine tool.

Having arrived at the situation shown in **photograph 1**, we are left with the requirement to remove a large amount of

Following the inclusion of a design of a ball turning attachment in the last issue that also explained the first stages of creating a ball handle, we include a brief follow up item on how to complete the exercise. This will not only be useful to those few who will actually require to carry out this task, but also as a learning tool for those new to lathe work.



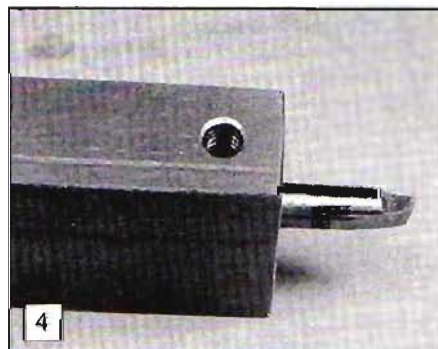
TURNING BALL



metal from between the two ends. The method which will be adopted for finishing the taper between the balls will permit only light cuts to be taken, and also have restricted access. In view of this, some easier method of removing the bulk of the metal will be advantageous.

Achieving the finish

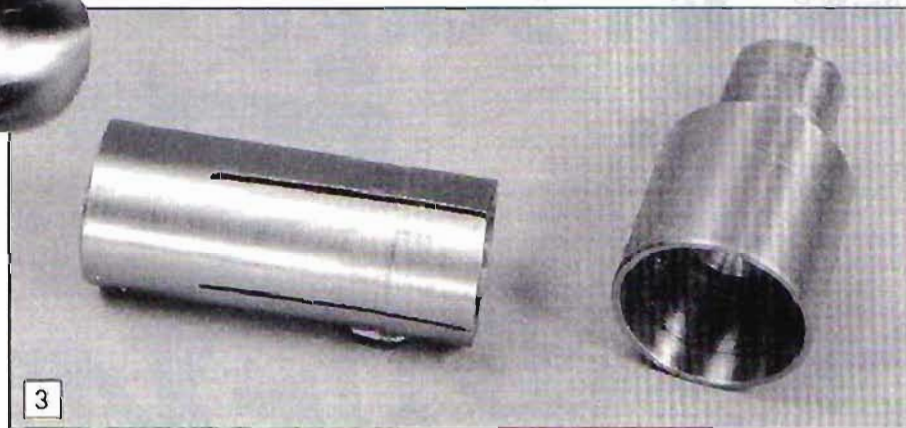
First though, the finish of the balls turned using the attachment is likely to be unacceptable, and will require improving.



The writer is not an advocate of the frequent use of emery cloth for finishing turned parts, but this is probably one case where there will be little option.

Use only a medium to fine grade cloth, and dry, which will give an appearance very approximately equal to a ground finish. If a highly polished finish is preferred a finer cloth will be required and used with light oil; this method will be very time consuming.

A word of warning here; do be careful, as working with the cloth in one's hands is a dangerous operation. It would be best to stick a piece to a length of wood and even with this approach great care must be taken. Finish both ends whilst the centre



portion is at maximum diameter and can therefore still be held in the three jaw chuck. If you have a collet large enough, using this would be preferable on safety grounds.

Removing the bulk

With the ends satisfactorily finished it remains to shape and finish the centre portion. Place the handle in the three jaw chuck, holding onto about half the length of the centre section and with the small end down. Now turn down the centre portion showing until it is just a little larger than the small ball.

Follow this by reversing the handle so the large end is visible, holding it in the chuck on the small diameter just produced. The large diameter can now be reduced in diameter to that of the largest end of the eventual shank between the two balls. This process has removed a large proportion of the excess metal as can be seen in **photograph 2**.

It should be possible to hold the smaller diameter on less than half the length of the shank. This will enable the shaft to be reduced to near finished diameter over more than half its length, as can be seen in the photograph.

It is now time to produce the tapered shaft and this must be completed at one setting. For this to be possible the handle will require to be gripped on one of the balls. It would be very difficult, though not

impossible, to adequately grip the handle on one end only, so as to turn the shaft without supporting the other.

It will therefore be considered necessary to grip on one end and to support the other. The obvious choice would be to hold the larger end as this would give the best grip. It will be seen later though that the smaller end is preferable.

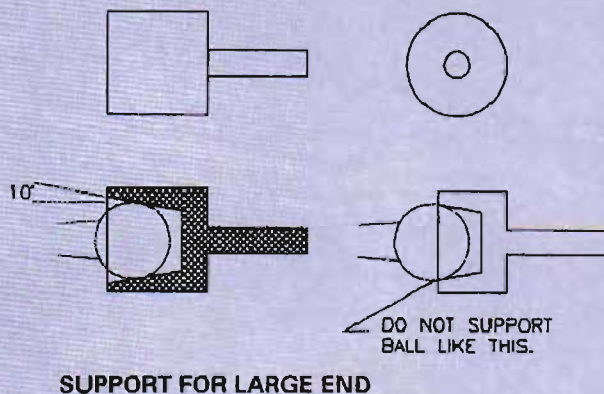
The fixtures

To grip the smaller of the ends, a split collar will require to be made generally as shown in the drawing. Note that it has a little larger diameter at the outer end to help ensure that it will grip the ball adequately (**Sketch 1**).

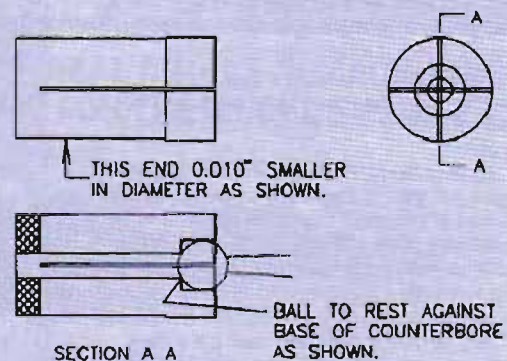
If a large enough internal rotating centre is available, this will be ideal for supporting the outer end. Otherwise you will need to make a suitable support. This can be as shown in the drawing (**Sketch 2**) and is for mounting in the drill chuck, or alternatively could be mounted onto an external rotating centre. If it is likely that it would get used quite frequently, making it with its own Morse taper may be considered worthwhile.

It can be seen that the internal angle is only about 20 deg. and at this angle the ball can be well supported whilst still leaving a little clearance. As it is not hardened, the clearance is important to maintain a film of oil. It is vital that the arrangement is run with plenty of oil and it must also be

SKETCH 2



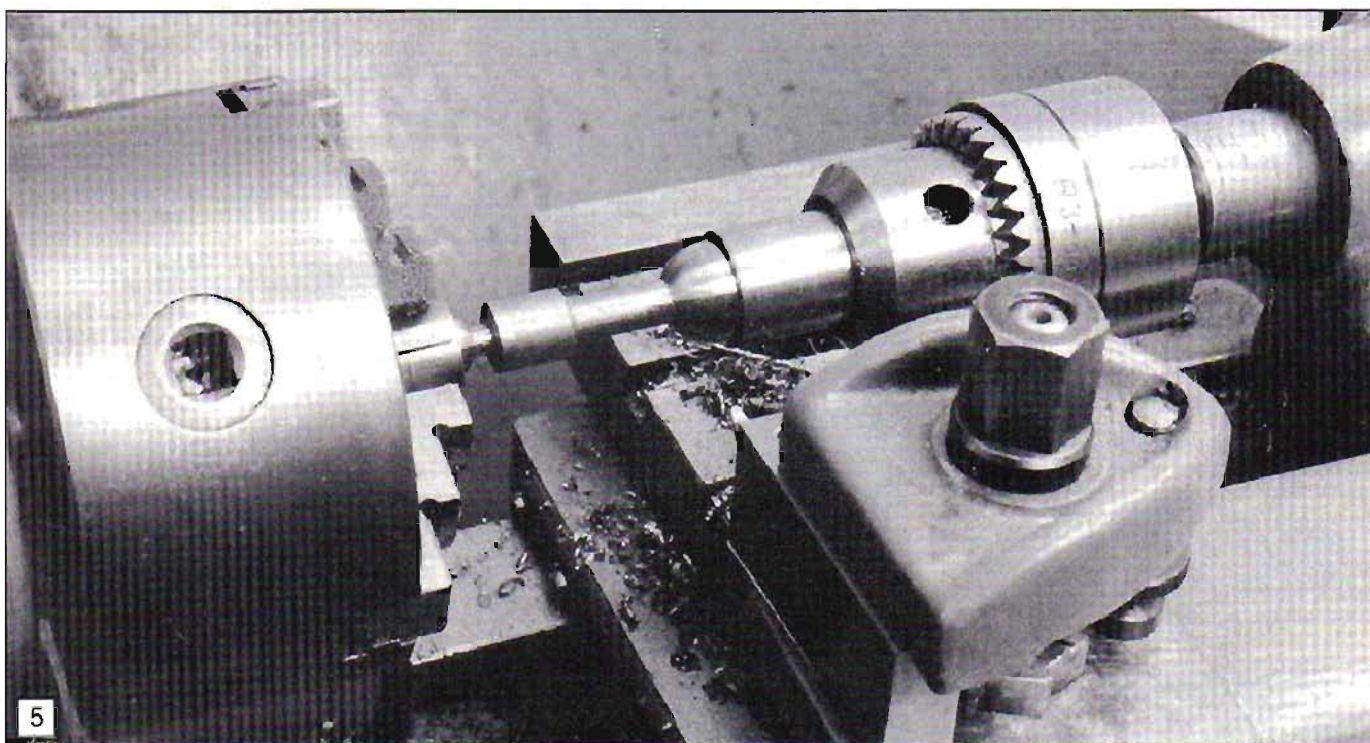
SKETCH 1



IDEALLY IF TO BE USED WITH A THREE JAW CHUCK, THE BUSH SHOULD HAVE THREE SLOTS AND NOT FOUR AS SHOWN.

SPLIT BUSH FOR SMALL END

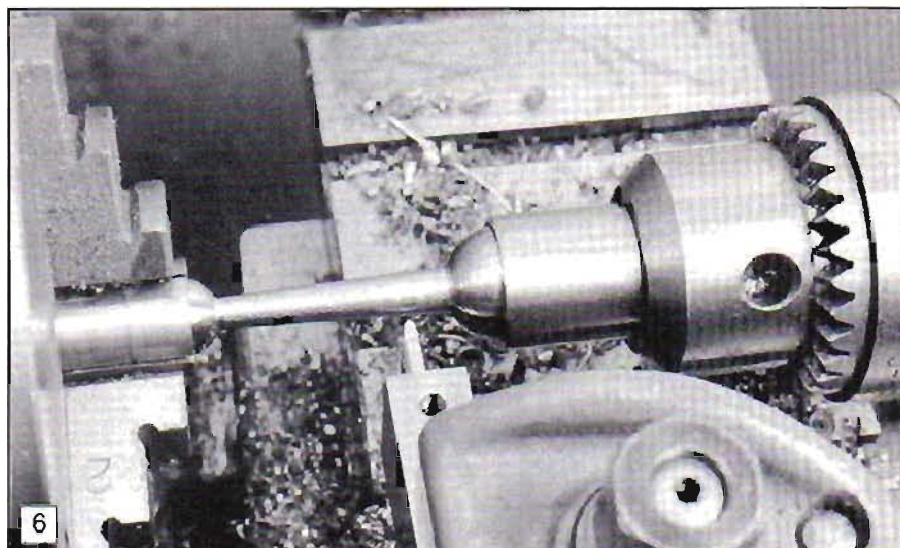
HANDLES



regularly checked to see that the clearance has not been taken up as a result of expansion of the part due to the heat generated. The shallow taper will also help to avoid problems as a result of expansion. These fixtures can be seen in **photograph 3**.

Fit the split collar in the chuck and the internal centre in the tailstock. Place the handle in the split collar, and tighten the chuck so that the ball is held very lightly. This will permit the outer ball to be moved to line up with the centre. Wind in the centre until it fully engages the ball then fully tighten the chuck. Adjust the tailstock again to ensure clearance between ball and support is present as indicated previously.

If a sharp corner between shaft and ball is preferred, then both left and right hand knife tools will be required. Alternatively, if a small radius is considered acceptable, then a tool with a narrow round nose will permit the shaft to be finished in one pass. The tool used can be seen in **photograph 4**.



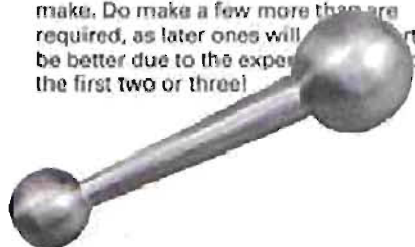
Taper attachment or top slide?

To achieve the taper on the shaft, using either a taper turning attachment or setting the top slide to the angle required are possibilities. If a taper attachment is available then this is definitely the way to proceed as, due to limited space, setting and operating the top slide can present a problem.

If, as is likely, the top slide has to be used, set this to the required angle. The choice of gripping the small end will become obvious at this point, as with the smaller end of the shank being nearest to the headstock there will be greater clearance between top slide and tailstock. This is shown in **photographs 5 and 6**.

Start by taking light cuts only to create the taper; as the process is continued experience will be gained to determine what depth of cut is permissible without the arrangement objecting in any way. If required, finish off the shaft with the grade of emery cloth to achieve the desired result.

If a Quorn cutter grinder is being made, there will be quite a few ball handles to make. Do make a few more than are required, as later ones will be better due to the experience gained on the first two or three!



7

Making the flat

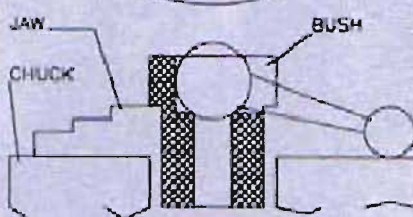
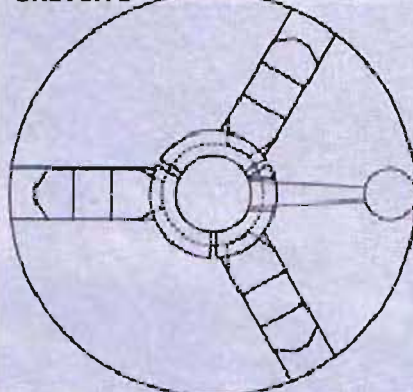
When the handle is complete to the stage seen in **photograph 7** it remains to make a flat on the larger ball and produce an internal thread. Making the flat and also the thread is best done in the lathe as both can be accomplished at the same time. Of course, they can be done on the mill and the drilling machine if preferred.

If the size of the three jaw chuck is large enough, in particular the amount by which the jaws project from its face, no other fixing will be required.

Mount a lathe spindle back stop and adjust its position such that, with the large end of the handle resting against it and the small end against the face of the chuck, the correct angle results. Protect the large ball



SKETCH 2



BUSH FOR INCREASING ANGLE OF HANDLE HAVING FLAT TURNED.

from the chuck jaws, using a strip of copper or similar. This arrangement is shown in **photograph 8**. Face off the ball to give the required flat and then drill and tap. The handle is now complete.

The jaw projection is important as it determines the maximum angle that the handle can take up. That achieved with the author's set-up can be seen in **photograph 9** and would probably be too shallow for most applications. If the jaws are insufficiently deep, then a bush similar to that made previously will be required. The drawing (**Sketch 3**) shows this arrangement and how the ball can be held in front of the jaw ends, resulting in a steeper angle.

Material

Turning a ball handle is quite a complex task and, because of this, will benefit from anything which will make this task easier. Most essential is the choice of material; do use free cutting bright mild steel as less machinable material will greatly add to the problems of obtaining a good result. This lesson was learned whilst making that shown in this article – and the effect can be seen ...

Ball handles?

Having explained one method for producing ball handles, I do hope this explanation proves of benefit, even to those who will never see the need to produce such an item. It is also worth considering, particularly if you only need one or two handles, whether this is the type of handle to use. Look at the handle on page 72 of the Dec 91/Jan 92 issue and compare it with that on page 36 of the same issue. Have readers any thoughts on the subject?



Quick Tip

Heating a Loctited screw or nut with a blowtorch past the operating range of the adhesive will kill the adhesive enabling it to be withdrawn easily but be careful since this method is not always desirable on some jobs.

Mr Langham

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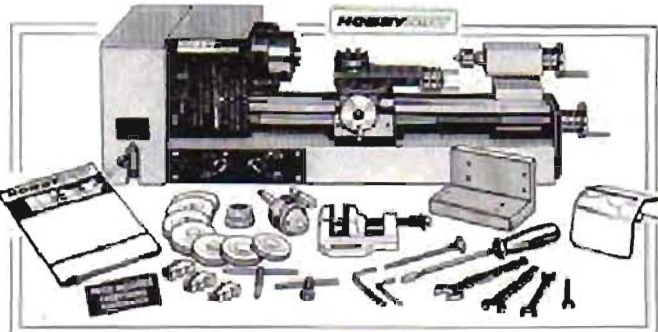
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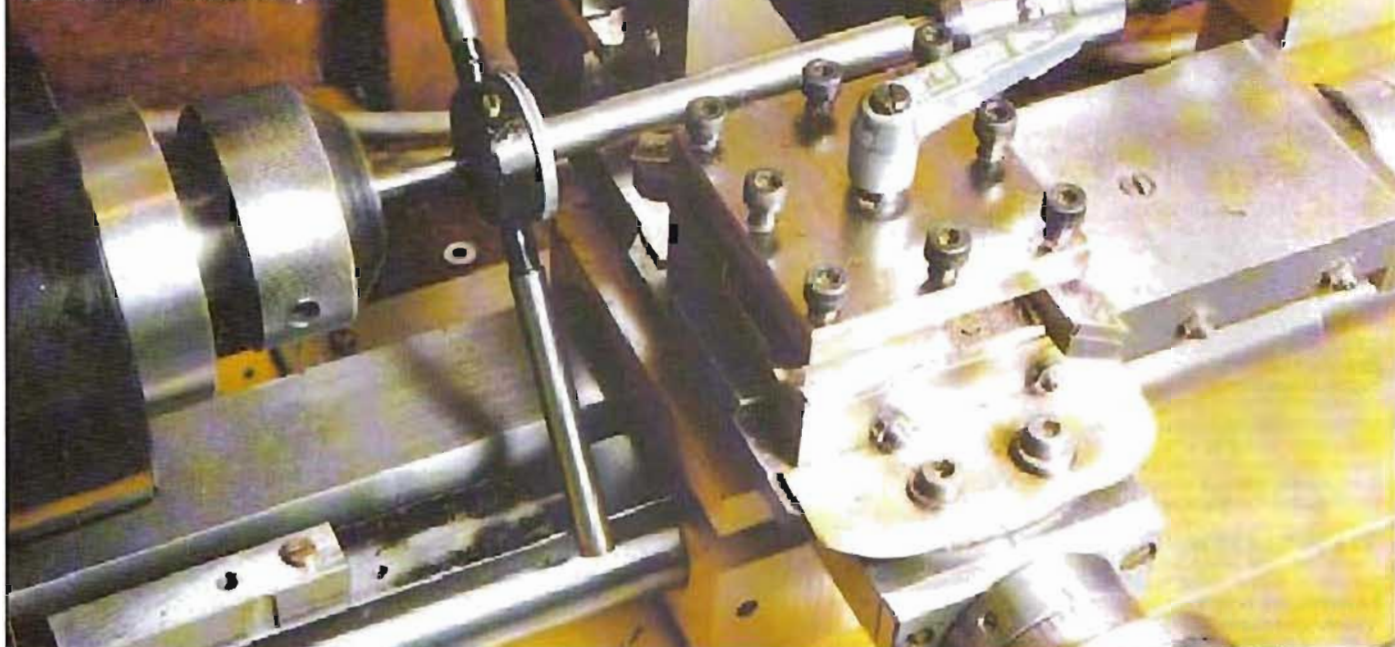
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The pusher in use, note how it slips nicely between the two tools. It is as well to check that the rear face of the dieholder is square to the axis of the die so that no inaccuracies creep in.



ATTACHMENTS FOR THE HOBBYMAT

Chris Ford, who's workshop was featured in a recent workshop visit, suggests these simple attachments for the Hobbylat MD65 lathe.

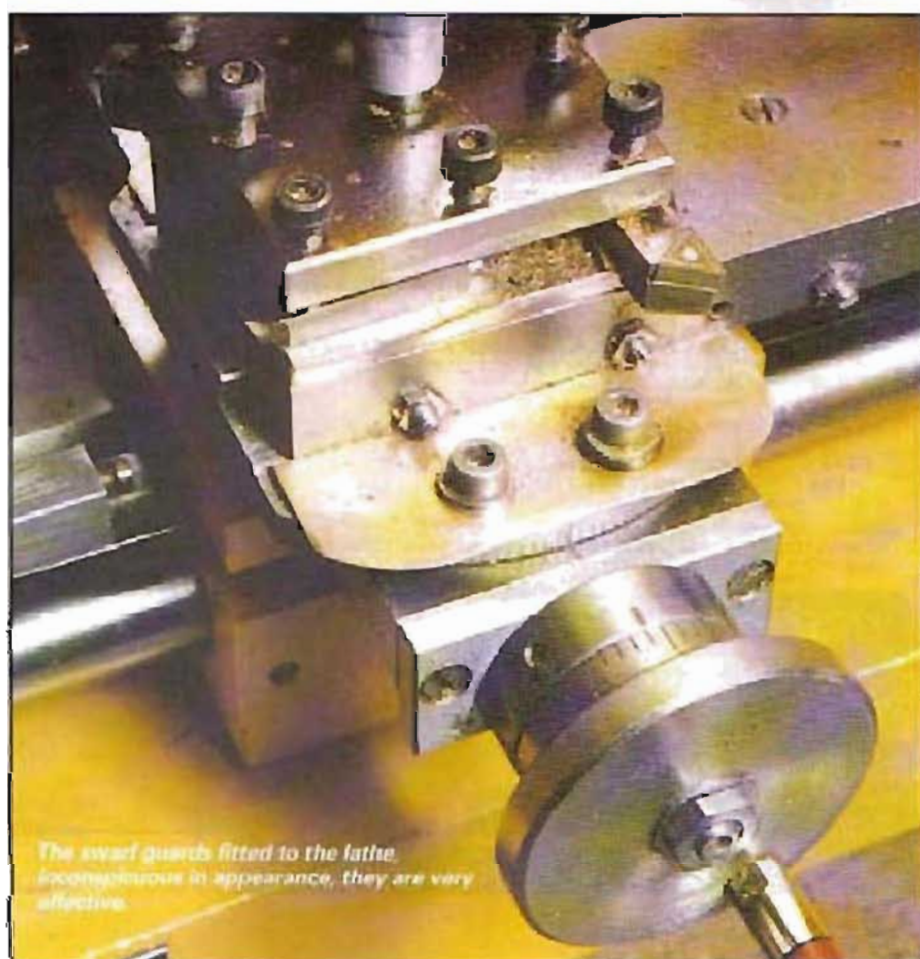
1 Tailstock "pusher" for use on a Hobbylat

With both front and rear tool posts in position on the cross slide, the clearance between the 2 tool posts is 1 1/4 in.

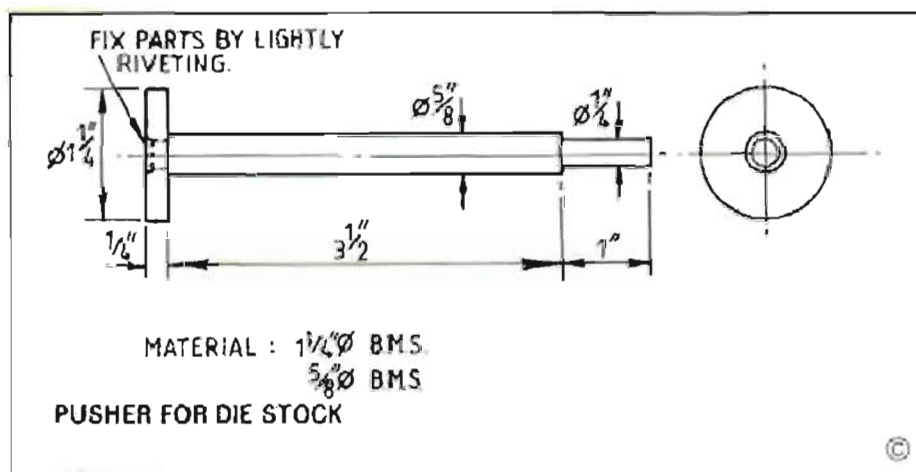
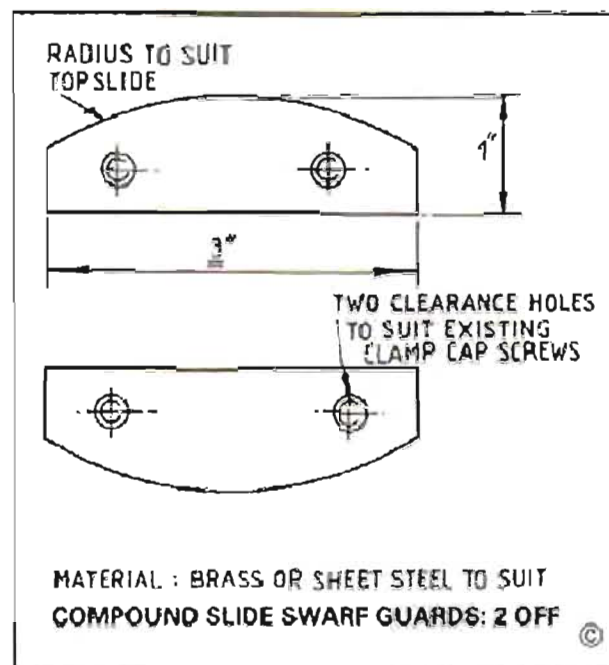
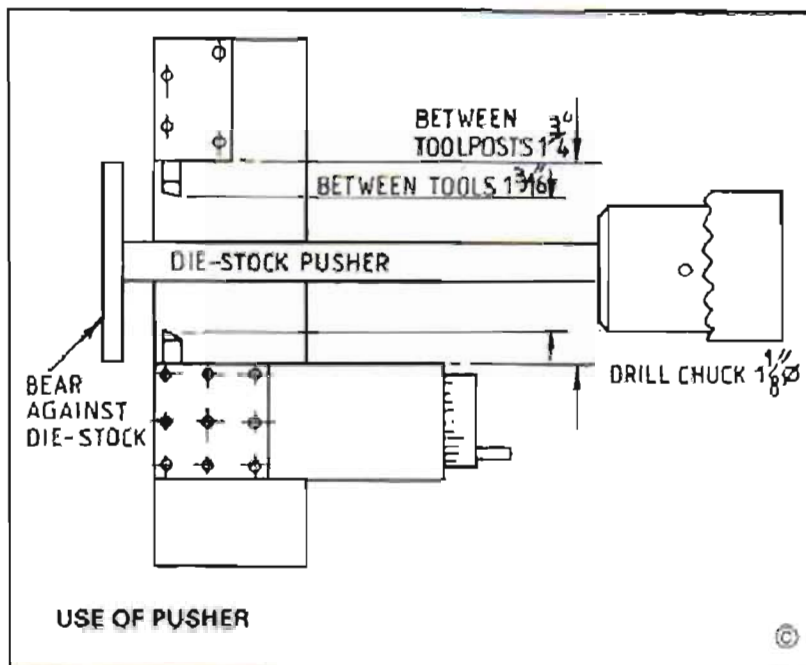
Place a tool in either tool post and the clearance is reduced to approximately 1 1/8 in. dependent on how far the tools extend, but this is about average. The diameter of a 1/2 in. Jacobs tail stock drill chuck is 1 1/8 in. and gives a modicum of clearance, but is not really practical when used.

With this problem in mind, I came up with the idea of a die holder "pusher". All parts were from the scrap box and can easily be made to suit the machine being used.

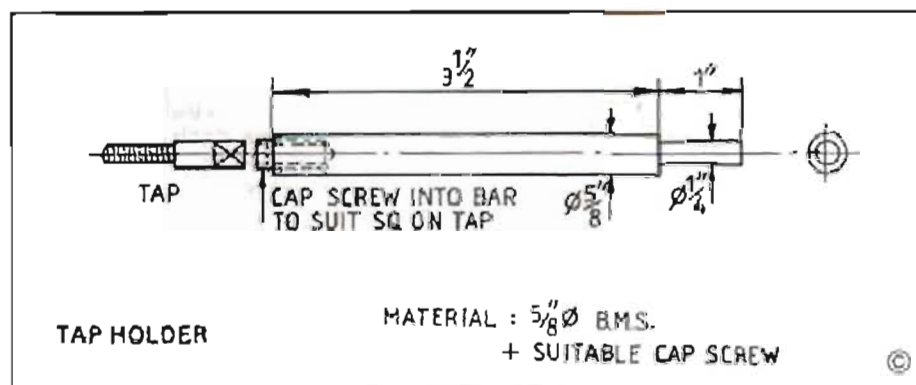
In use, the traditional die holder is placed on the chuck/held shaft etc. to be threaded. The "pusher" is held against the back face of the die stock, between the 2 tool posts and located in the Jacobs



The swarf guards fitted to the lathe. Inconspicuous in appearance, they are very effective.



Simple yet extremely effective, the completed die pusher.



tailstock chuck. Pressure is then applied as normal by the bed locked tail stock quill.

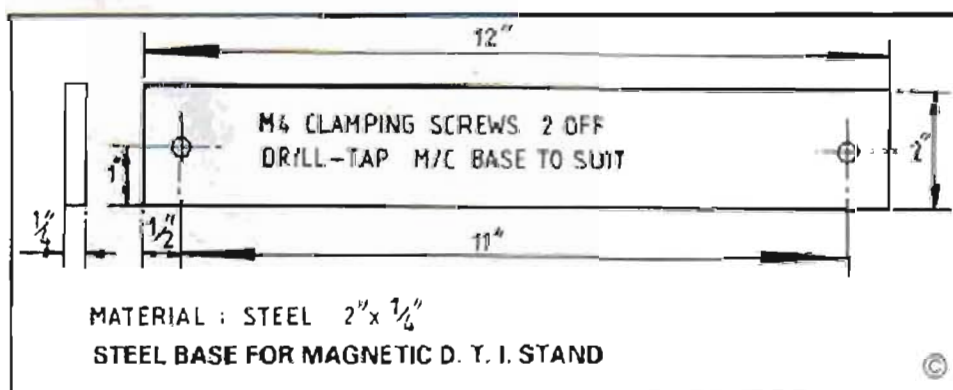
To make an extended holder for holding taps, drill and tap a straight bar to suit a socket headed cap screw. The drive square on the tap will fit in to the hexagon of the cap screw and hold the tap square. Obviously, different sizes of tap square will necessitate different size cap screws.

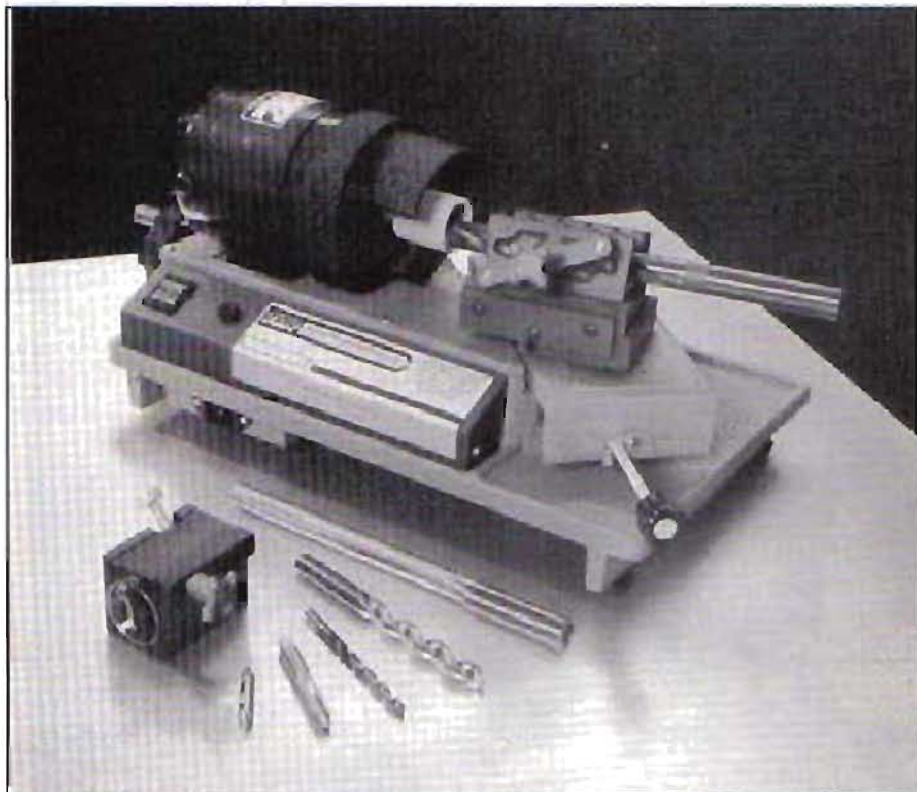
Swarf guards for compound slide

To prevent the ingress of swarf etc. into the 2 circular division slots, obtain 2 pieces of sheet material approximately $\frac{1}{4}$ in. thick. Remove 2 of the compound slide clamping cap screws. Cut the material to size, drill 2 clearance holes to suit. Place guard in position and re clamp. Repeat for the other guard.

Steel base

Due to the base of the machine being a non magnetic material, a magnetic D.T.I. base will not adhere to it. I simply bolted a piece of flat plate 12 in. x 2 in. x $\frac{1}{4}$ in. on to the base of the machine. Two holes drilled and tapped in the cast base are sufficient. I find that with the magnetic base/clock assembly on the rear of the machine out of harms way, run out of chucked components is easy to see. Also, for accurate groove depthing the pointer of the D.T.I. can be set on the rear of the cross slide to check for absolute cross slide accuracy.





The S. R. D. Sharpening Machine, together with some of the tooling, and some of the tools it can deal with.

MACH '92

This very brief report of the International Exhibition of Machine Tools and Manufacturing Technology, indicates that it can be of considerable interest to the home machine shop enthusiast. It is true to say that there is little of practical benefit, most of the exhibits are aimed at the industrial end-user

The International Exhibition of Machine Tools and Manufacturing Technology, "MACH92", was held at the National Exhibition Centre, Birmingham during the 6th to the 15th May.

Any home machinist with an interest in machine tools in general, and a good pair of legs also, would have found this a very interesting exhibition to visit. With almost 600 exhibitors and taking up halls 3, 4, 5, 6 and 7 of the N.E.C., it was an enormous task to see it all. The individual visiting the exhibition hoping to find more than just a few items applicable to the home workshop, would though have been disappointed...

There were eight exhibitors who also had displays at the International Model Engineer and Modelling Exhibition, but most of these were displaying items outside of the scope of the home workshop. Typical of this was the very large Emco Maier stand on which they were displaying their wide range of small to medium size automatic turning centres. There was also a small number of manufacturers such as Scot Urquhart Ltd who advertise in *M.E.W.* and *M.E.*

A large number of the machines were

powered up and able to work; some are very large making this exhibition a massive project to set up.

In addition to turning and milling machines, perhaps the main interest of the home workshop enthusiast, there was a section devoted largely to sheet metal working and it was here that most of the largest machines were to be seen. It was also by far the noisiest part of the show!

The largest

One very large machine that interested me, and was working, was an automatically loaded and unloaded cut off saw. This automatically took lengths of steel bar, some up to 5 inches diameter, from a racking system containing many different sizes of bar and loaded them into the saw, cut off the required length then returned the remaining piece to the rack - all under computer control.

The smallest

At the other end of the size range and probably the smallest machine at the exhibition was drill sharpening machine made in Franklin N.J., U.S.A., by Service Precision Grinding. This is supplied in this country by a company well known to readers of this magazine, Jabus Engineering Ltd.

The machine used a method that was new to me and was simplicity itself. Unfortunately, for justifiable reasons, this still did not make it a cheap machine though it could be considered a possibility for, say, a model engineering club.

The machine had the drill mounted on a slide, rather like the top slide of a lathe, set to an appropriate angle. The drill did not rotate and the grinding wheel just rotated on fixed bearings like any hand grinder. Even so the machine would automatically grind drills of any size to the precise shape required, and in less than a minute. The most useful machine covers a range of from 1.5 to 21mm. Perhaps readers may like to consider how they think this can be achieved; a review will be published in a future issue.

Small tools

In addition to machines there were a large number of stands displaying small tools and other accessories, though being aimed at industry they were mainly rather expensive.

1994

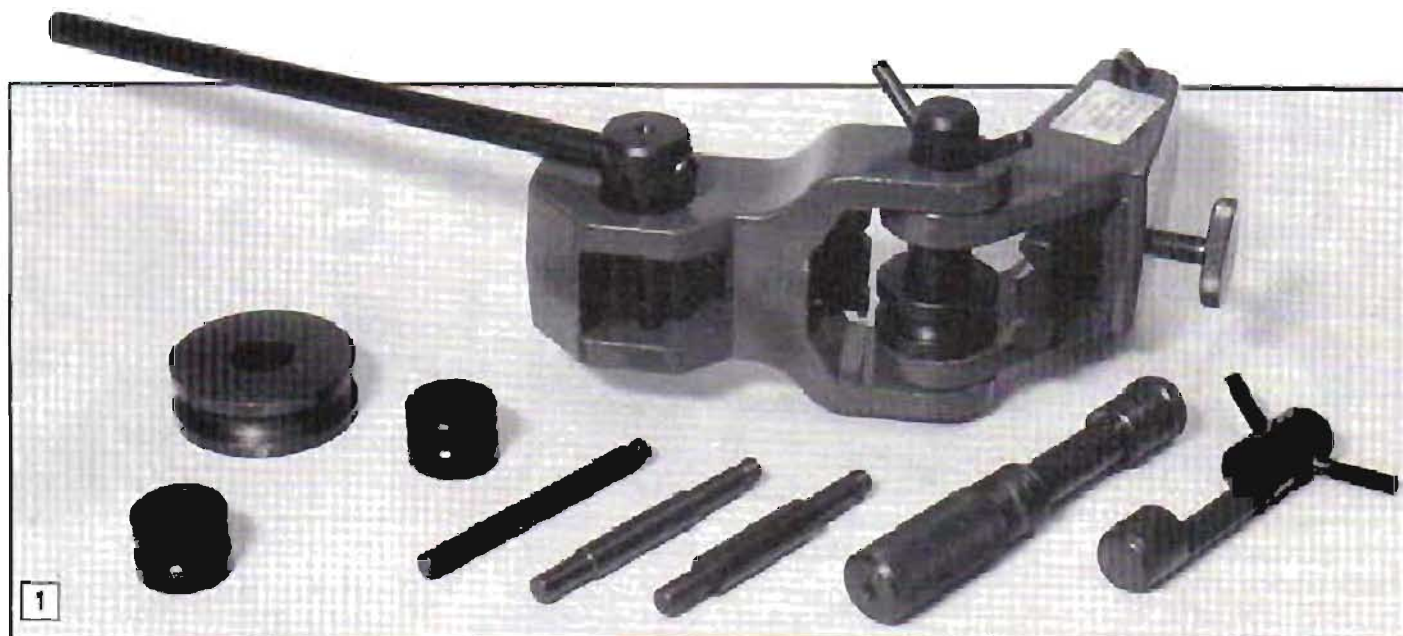
This exhibition is held every two years so if you consider that you may be interested, look out for the date early in 1994. For details of the drill sharpening machine, the address of Jabus Engineering Ltd, is: Ash Barn, Broughton, North Devon EX33 2EG Tel. 0721 815310.



A close up of a drill being sharpened in the S. R. D. Machine.

QUICK TIP

A stack of "panny" or repair washers, drilled and riveted on one edge makes a handy packing for use on milling machine or the lathe's faceplate. Just fold out the ones not required, to get an instantly setting height adjustment. They will sit nicely on a nail on shelf when not in use.



Most readers I feel sure will have at some time required to make a part involving the need for bending metal bar, strip or tube. Most, like me, will have at some time struggled in an attempt to produce a satisfactory result using a bench vice and a piece of steel bar to act as a former. This approach has probably been time consuming, and frequently resulted in a less than ideal end product.

The **Universal Bender** reviewed in this article is a serious attempt to overcome the problem. It does, within the limits of its capacity, produce a wide range of bends with surprising simplicity.

VEB Spann-und Biegewerkzeuge of Germany are the manufacturers, and it is distributed in the UK by C.Z. Scientific Instruments Ltd. Their published specification for the bender states that it will bend up to 40mm wide and 4mm thick in strip (3mm thick for sharp corner bends as seen in photograph 4) and bar up to 10mm diameter. Tube with outside diameters of 4, 6, 8 and 10mm can also be bent.

Test showed these figures to be very attainable, the force required to make the

UNIVERSAL BENDER

The tool from C.Z. Scientific is one capable of a surprisingly wide range of applications. It is a tool which could be useful in any metal working shop where forming and bending operations are carried out.

bend, being in most cases, surprisingly low. Even with 8mm solid bar the bend as can be seen in photograph 3 was made very easily.

An attempt to bend 10mm was less successful, though this was largely due to the vice being inadequately fixed to the bench. The vice being used was fixed to a small block of wood which in turn was then

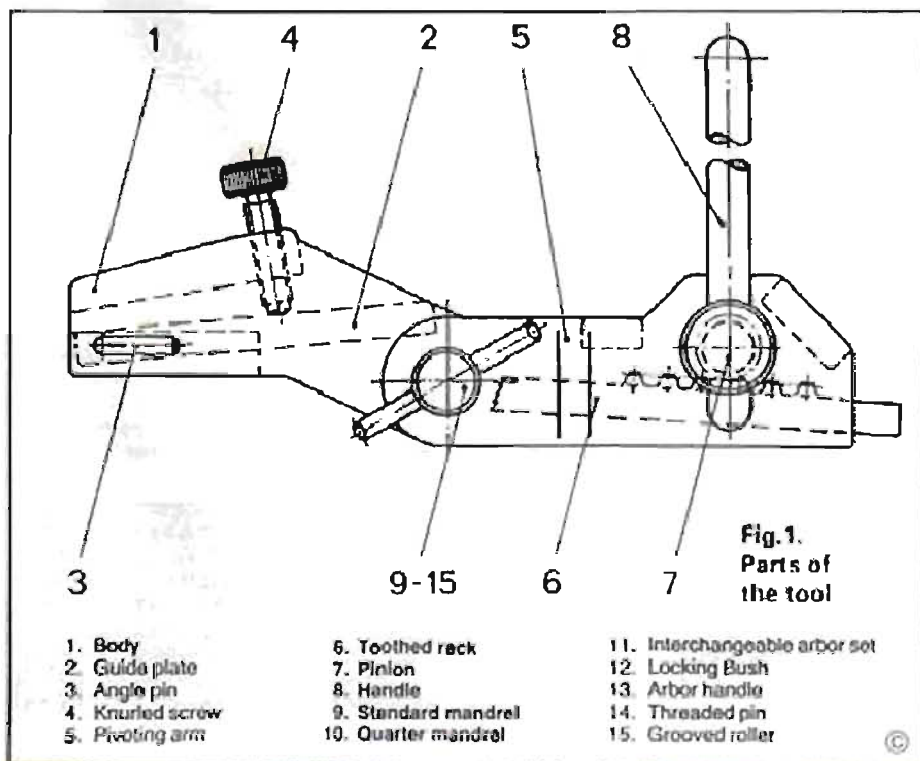


fixed to the bench using two G clamps. The purpose of this being to enable it to be removed to provide more bench space.

The bender is extremely simple and quick to use, with only one exception, parts just slide easily into place without the requirement to be fixed in any way. The one exception to this is when bending smaller internal radii. In this case the mandrel is made up from three parts and requires a grub screw to be tightened using a small screwdriver.

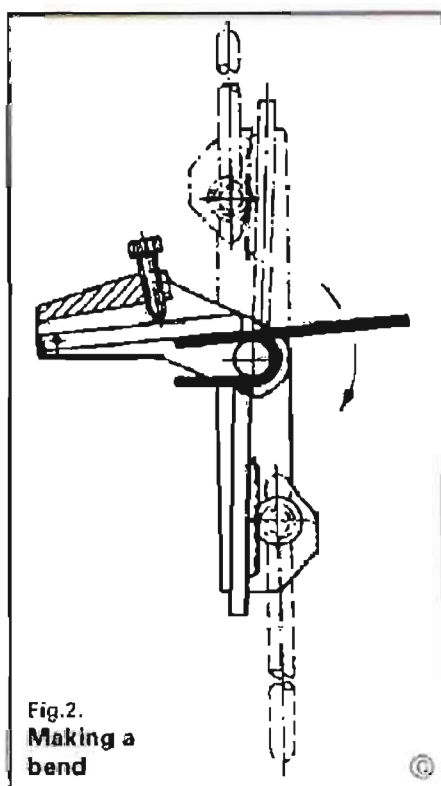
Probably the most difficult aspect of using the bender will be that of ensuring that the bend is made in the correct position along the length of the part being made. Also requiring some careful thought will be order in which bends are established for a multiple bend item.

Positioning the bend will present few problems once it is realised how the bender functions, this being probably different to that anticipated when the bender is first considered. More about that later.





SOME OF THE SHAPES WHICH CAN BE MADE



grooved roller for bending 6mm diameter bar, and to give an internal bend radius of about 30mm. **Photograph 2** has an 8mm diameter mandrel for bending strip.

To complete a bend, with the body (1) fixed in position and the pivoting arm (5) in the position shown dotted in **figure 2** a straight piece of metal is inserted as shown. This is placed between the guide plate (2) and the required mandrel (9-15). The knurled screw (4) is then used to lightly clamp the workpiece between the guide plate and mandrel.

be made in the position anticipated. With this understood there is very little problem in positioning bends.

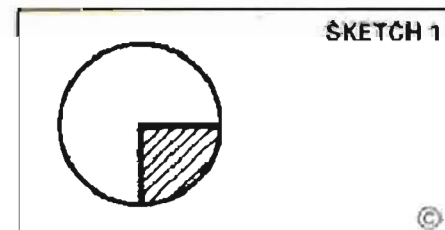
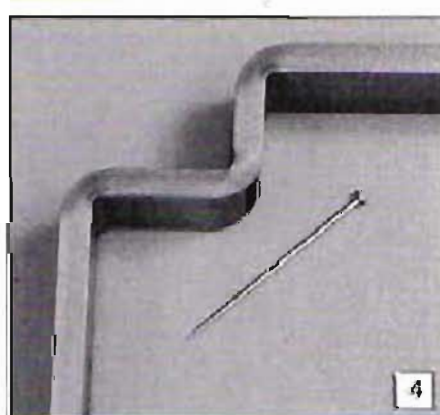
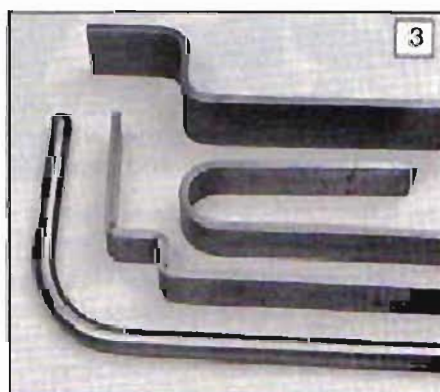
The instructions recommend that the guide plate is lightly greased to aid this movement of the material along its surface.

Bends can be made to any angle required, including making a part with a closed loop, except for tube which can only be bent to a maximum of 180 degrees.

Type of bends

Photograph 3 shows a small range of bends that were attempted; all were achieved with ease. The bar shown is 8mm diameter and the widest strip 25mm x 3mm.

Photograph 4 gives an indication of how close bends can be made to each other, the material in this case is 15mm x 3mm. To achieve bends with quite sharp inside corners as seen in this photograph, a mandrel is available which has been machined to leave a 90 degree segment of a circle (**sketch 1**). This can be seen as the right hand mandrel in photograph 1.



Conclusions

The unit is a well made item and very robust, and if used within its recommended limits of material sizes there is no reason why it should ever fail in any way. Even if used frequently it should have a life of many years.

It is very simple to use even when producing quite complex shapes as seen in the range of examples shown. The bender can be purchased from a wide range of suppliers who advertise in *M.E.W.* If any reader is unable to locate a supplier contact C.Z. Scientific Instruments Ltd (081-953 1688).

If any reader requires more detailed instruction on the use of this tool a short series appeared in our sister magazine Model Engineer. The series commenced on 19 April 1991. Photocopies are available from Photocopy Service, Argus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST Ed.

The full kit of parts is shown in photograph 1. These come in a moulded polystyrene box with positions for each part. This also has a recess for the flat polystyrene lid which is included. With a little care this could provide tidy storage for some time, though being polystyrene its life will be limited. The case now available and described elsewhere in the trade pages would be a good buy.

In use

To use the bender it is held in a substantial bench vice by gripping onto a tang which is part of the body. **Item 1 figure 1**. Unfortunately this tang is not visible clearly in **figure 1** or any of the photographs. It is though represented by the dotted rectangle, bottom left hand corner of the body.

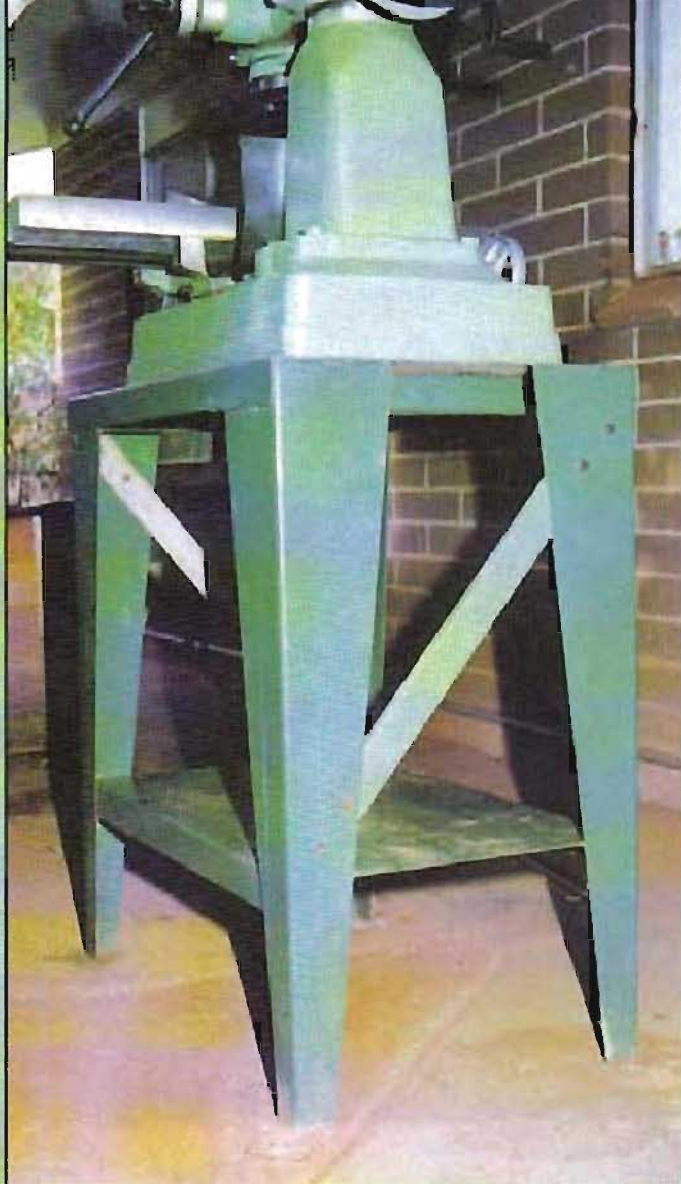
If a permanent location is preferred for the bender this tang can easily be drilled and bolted to a suitable location.

With the bender in position and fitted with the required mandrel (items 9-15) bending can be commenced. **Photograph 1** shows the unit fitted with mandrel and

The handle (8) complete with pinion (7) is now rotated, which will advance the rack (6) until it contacts the workpiece. If the handle is then further rotated the pivoting arm will commence to rotate and the bend made. It would be easy to fall into the trap of expecting the end of the rack (6) to slide around the material as the bend is made. This is not so, in fact the rack grips firmly the material against the mandrel and the material slides between the guide plate (2) and the mandrel. For this reason, if this misconception is made, the bend will not

A MILLING MACHINE STAND

John Cartwright of Newman, Australia provides this simple but effective design for a milling machine stand. It is realised that few readers will have facilities for guillotining and bending, but if this were to be carried out by a local sheet metalworker, the assembly would be a useful exercise in welding.



The completed stand; note that the cross braces have been bolted to the main assembly. The table is bolted to the floor by rag bolts let into the concrete.



An underview of the machine table showing the strengthening piece for the feet of the machine.

Having recently purchased a mill/drill which weighed 300 kg I needed to design a very sturdy support stand.

The design I came up with has proved to be an excellent choice. It is fabricated from 3mm mild steel sheet. I had ready access to a hydraulic bender and a guillotine which certainly made the job easier. My next door neighbour had also purchased a similar machine so I undertook to make two support stands. The standard sheet size in

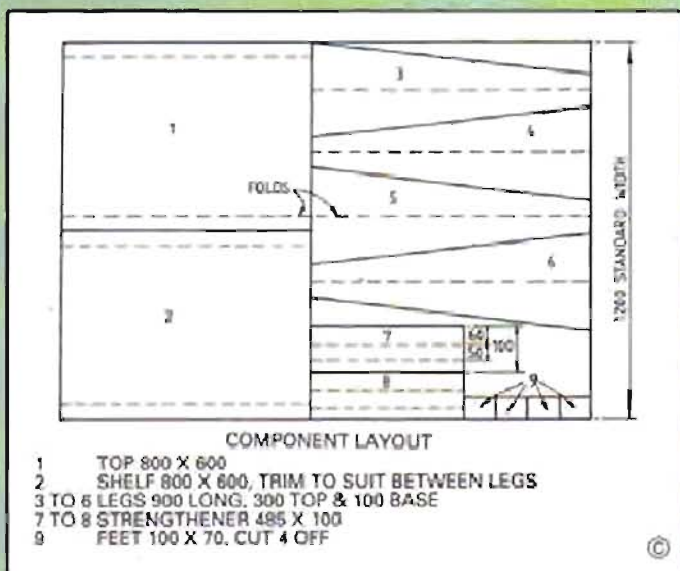
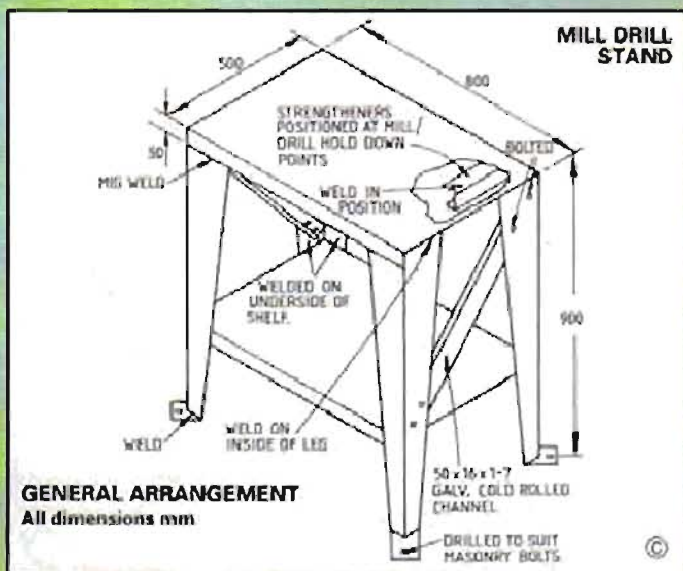
Australia is 3.9m x 1.2m x 3mm, so we shared the cost of a full sheet.

From marking out, cutting, bending and MIG welding the pieces together took a total of 3½ hours. In fact it took longer to paint them than it did to make them.

The mill/drill was put into position and bolted to the stand. Machine and stand were then levelled and bolted to the concrete floor with masonry bolts. About the only problem I encountered with the

stand once the mill/drill was in place was that the stand flexed across its width. This was overcome by bolting two diagonal braces as shown. The braces were made from 50 x 16 galvanised cold rolled channel.

(Do not attempt to weld galvanised sections to this fabrication – the galvanising when melted by the electric arc gives off dense fumes, which can be harmful to health if inhaled – Ed.)





The reason

Unlike most classes where the reason for attending will be almost identical for each member of a given class, those attending an evening in the college workshops will be there for widely differing reasons.

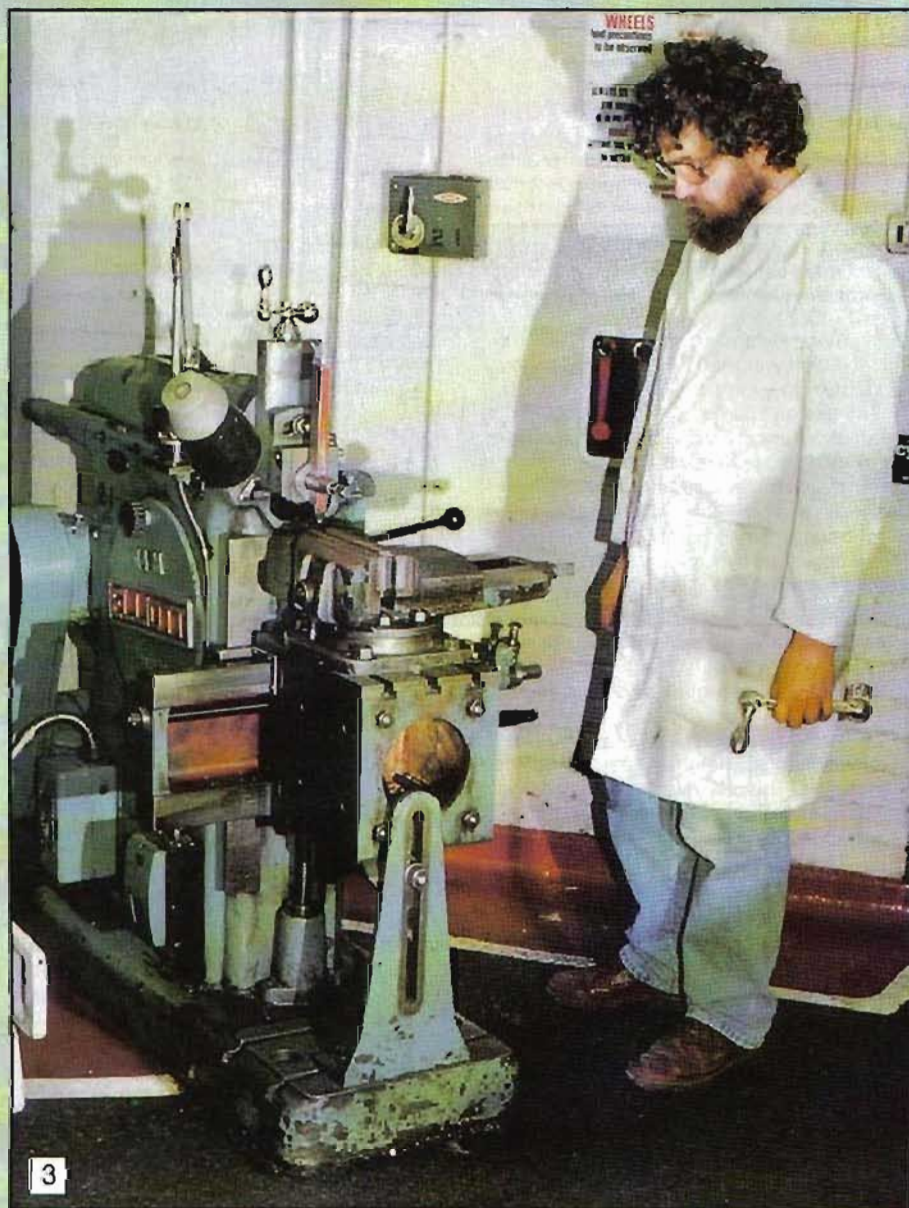
The college prospectus is likely to have the class (?) listed as a Model Engineering evening. This is understandable, as the event has to have some title, and a large proportion of students (?) attending will be there for that specific purpose. Even so, there will be those, perhaps as many as 50%, attending for other reasons. Do not be put off considering attending if your interests are not model-making.

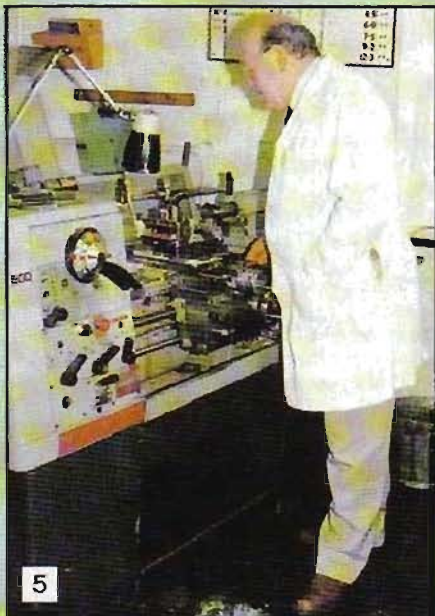
You will see that I placed a question mark after 'class' and 'student' in the above paragraph, the reason being because many who attend will require little or no instruction and can hardly be called students – being there just for the use of

BACK TO COL

Expand your workshop's capabilities by enrolling for a term at the local college. Read on and see what benefits are likely to be yours as a result.

Our recent reader survey showed that only some 16% of readers attended evening classes or similar, this low value no doubt being in part due to many readers being too far away from a suitable venue. Although reasons for not attending will be many and varied, for some perhaps, ignorance of the potential benefits may be the main one. This brief article sets out to correct this ignorance and to encourage more to make use of the excellent facilities available to them.





the equipment available. If, on the other hand, you are new to the use of metalworking machines, tutors will be on hand and help will be given.

For many who attend, the main benefit will be the availability of a wider range of machines than those found in the average home workshop.

The equipment

A complete range of industrial machine tools is likely to be available. These will include such items as, horizontal milling machines (**photo 1**), vertical milling machines (**photo 2**), shaping machines (**photo 3**), surface grinders (**photo 4**) and cylindrical grinders, etc. Even the experienced home machinist may require tuition in the use of the cylindrical grinder ...

Even machines such as the lathe and the drilling machine which are likely to be found at home, will be available in much larger sizes (**photos 5 & 6**).

Of additional advantage will be availability of the full range of ancillary machine equipment; to be found in the tool store manned by a storeman will be drills and cutters, boring heads, rotary tables and

dividing heads, etc. (**photo 7**). There will be no need here to make do with inadequate equipment.

For those who like to make tools which require to be hardened, the presence of temperature controlled ovens (**photo 8**) will cut out the guesswork. No more heating with a flame of some description to the colour of boiled carrot, the colour of which will appear different depending on the level of the ambient light present. Due to the length of time these ovens take to heat up, it will be necessary to inform the college of the need to use one, so that it can be started up earlier in the day.

Sheet metal fabrication

Unfortunately, as in industry, sheet metal work is considered another discipline and will be catered for in a separately equipped workshop. This means that for wide use of these facilities it will be necessary to enrol for another class in fabrication. However, it is probable that if a small amount of sheet is required to be guillotined, this can be arranged by the machine shop tutor.

The metal fabrication courses will include tuition on the various forms of welding, and as a result are likely to be more tutorial than the machine shop evenings. Any reader contemplating purchasing and using welding equipment for the first time would be well advised to attend such a course for a term (around 12 weeks).





Those attending

For this article I have attended two colleges, the Windsor and Maidenhead college at Maidenhead and the Dacorum college at Hemel Hempstead; I would like to thank the staff at both colleges for their help in making this article possible. Both classes had around 25 people attending; I found a wide range of abilities and there would be no reason to feel out of place if only a beginner, or on the other hand, a very skilled toolmaker.

Both machine shops had plenty of machines (50 plus) and access to a machine was rarely a problem. A few attended who had very little in the way of a home workshop and the course would seem a good idea for such people to try out their potential skills before embarking on the expense of setting up their own workshop.



Another aspect of attending such an evening's activity is that it enables one to meet with others having similar interests – otherwise most would be working in isolation unless alternatively a model club were joined which would only be appropriate for those involved in modelling. Having paid the fee, it is also probable that this will give some impetus to keep at the project, and not let it slide for a few weeks.

The activities

Model engineering was the most prominent activity but a number of those attending were restoring vintage transport (not the bodywork, the fabrication course is

It may also be possible to attend sessions held in the daytime. The Maidenhead college also ran a week-long summertime session for which they even offered to arrange accommodation for those travelling from outside the area.

The benefit of the daytime and, in particular, the week-long course, is that, being a longer session, the need to break off a task before it is complete is much less likely. This perhaps is the only weakness of attending evening courses: some planning is required to ensure that projects are finished before the end of the evening, it is a requirement that the machines are vacated to make them available for the next day's students.



for this). **Photograph 9** shows such a part being turned.

Some were making or restoring workshop equipment and **photo 10** shows the drive for a Myford ML2 being converted from flat to vee belt. Making these stepped pulleys on the lathe itself would have been a time-consuming if not impossible task. Using the larger lathes available made this task much easier and quicker.

Another member of the class had a full-size steam locomotive for which parts were being made to aid restoration. In fact, if the activity can be done on the equipment available, anything is permitted – perhaps with the proviso that it is not part of a commercial activity.

The course

The courses will vary in composition depending on the college, as also will the cost. Typically though the evening will be two and a half to three hours and there will be either two or three terms of from 10 to 15 weeks, each term being booked separately.

Costs would appear to vary widely and as a result I will not attempt to detail these. As a rough guide, an average 12 week course may cost about £40 – £80. Reduced prizes are often available for pensioners and the unemployed, etc. However, if a reader is within reach of a number of colleges some shopping around may be worthwhile ...



Materials

All materials must be provided by the student, though to a very limited extent the college may be able to help with small requirements. This is likely to vary widely from one college to another.

Enrolment

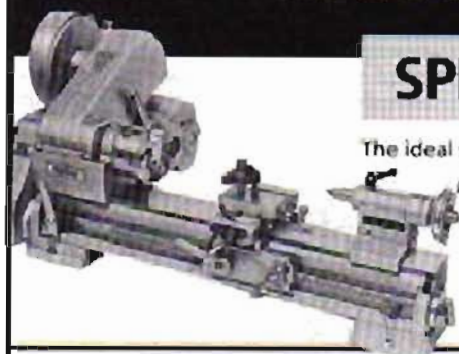
It will shortly be time for enrolment for the first winter term, so why not give it a try? It may be that enrolling for the occasional term would be a good idea, for those one-off projects which are just too large or complex for the equipment available in your own workshop.

If your local college does not advertise such courses, enquire: some prompting may encourage them to get one started!



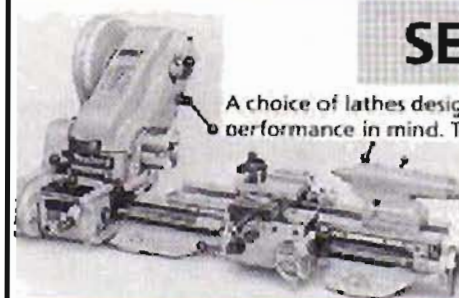
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MILLING

PART 3

FOR BEGINNERS



Having dealt with the equipment side of milling in the past two issues, actual milling operations are now being discussed.

In the previous two instalments of this article the questions of work holding, and cutters and cutter holding, have been considered. It now remains to expand on the subject to include the actual milling operations.

Some articles being published in *MEW* are predominantly milling exercises. These are being covered in greater detail than is normal, so as to back up this series. See the article on the Precision Level published in the April/May issue, and the vice improvements elsewhere in this issue.

Before commencing machining there are a number of decisions to be made and some actions to take as follows:

- 1) Choose the type of cutter to be used.
- 2) Choose the method of holding the work.
- 3) Position and fix the work holding device, and the work itself, on the machine table.
- 4) Fix cutter in machine.
- 5) Choose cutter speed.
- 6) Position workpiece relative to cutter.
- 7) Adjust to give width and depth of cut considered acceptable.

The wide variety of methods of employing a milling machine make writing a short article explaining its use a difficult task. Frequently whole books on the subject still leave much to be said. In any case, as this article is aimed at the beginner, the basic details only are included.

1. Choice of cutter

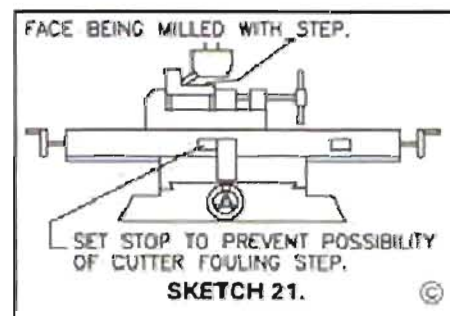
There will, of course, be some instances where there is little choice to be made, as the article being machined will demand a particular cutter. Examples of this will be making a gear or slitting a part with a slitting saw. But for more general work the type of tool employed is not that definite and, as a result, some choice is open to the operator.

It may be that, to avoid tool changes, a compromise will be adopted, perhaps resulting in a tool being used, due to it already being in the machine or required for the following operation, which otherwise would not have been chosen. Similarly, due to the limited range of cutters available in the home workshop, the ideal cutter may not be used as it is simply not to hand. As a general rule the following basic approaches would be adopted.

Large surfaces

For a large, flat surface the first choice will be a fly cutter, or alternatively the face cutter provided with many machines. Whilst a normal end mill could be used it is not really intended for this purpose and its use in this manner is likely to be a slow process, and produce an inferior finish – at least from a visual point of view though maybe not if measured.

If the large surface has to be machined into an upward facing step, the fly cutter will require to be sharpened with a sharp corner and an upright outer edge. A small radius of a few thou. though would be essential – even more if the component would permit it.



The vertical portion of the cutting edge should not be much greater than the maximum depth of cut likely to be taken. This will prevent the possibility of a wide cut, which would put undue strain on the cutter.

An added precaution when machining a step in this manner would be to set the table stop, this to prevent the cut being inadvertently set too wide at this point. See **sketch 21**. Rather than make a fly cutter with a sharp corner to produce the step, the bulk of the removal could be done with a normal fly cutter. The radius from inside the step could then be carefully removed, with the final cuts being taken using a normal end mill. Alternatively the whole process could be completed using a normal end mill.

Small surfaces, steps and slots, etc.

For smaller surfaces, also steps and slots, the obvious choice is an end mill – or is it? For the beginner, all cutters with a parallel shank and intended to use the end portion for cutting, will be considered as end mills. This is understandable even though there are outward constructional differences.

The cutters will at first sight appear to be identical, other than the fact that they have probably either two, three or four cutting edges. Even on closer examination the differences apparent may appear insignificant.

Reference to a catalogue will show that the four flute cutter is called an 'end mill', whilst the two and three flute will be called 'slot drills'. Even with this knowledge it is still easy to overlook the real significance of these names.

These milling cutters are expensive and the first thought is likely to be that as there is not much difference only one type need be purchased. This is reasonable providing that the limitations are realised.

The major difference is in the end cutting edges. For the end mill these edges do not go to the centre of the tool, but on the two and three flute cutters one edge is longer than the others and crosses the centre. This can be seen in **photograph 1**, the right hand cutter being a slot drill whilst the remainder are end mills. This permits the two and three flute cutters to be plunged into the workpiece rather like a drill. The part can then be traversed sideways to produce an enclosed slot – hence the name 'slot drill'.

Having only two or three cutting edges gives greater clearance for the swarf which can be a problem when cutting slots. In this process the swarf is more difficult to clear, and the larger flutes improve the situation. This is more of a benefit to high quantity production milling, and somewhat less relevant to the home workshop.

End mills are to be preferred for all other work due to the increase in number of cutting edges. These make it possible to remove material more quickly, or alternatively reducing the work load per tooth and maintaining its cutting edge longer. Also important, the construction of the end mill makes it more rigid, and as a result less likely to break or chatter under heavy load conditions.

If the cost of purchasing both types cannot be justified, then all is not lost. By taking the necessary precautions, enclosed slots can be produced using a standard end

mill. To achieve this the end mill can be plunged into the material by a few thou. only. If the cutter is plunged much deeper than this, then a substantial raised portion will remain in the centre of the end mill. The effect of this can be seen in **photograph 2**. Any attempt to traverse the work under these conditions will result in extreme sideways force being applied to the cutter, this due to it being unable to remove the raised portion. The reason for this will be obvious if an end mill is examined closely. If this precaution is ignored broken cutters and damaged work will result. Another approach would be to pre-drill a hole as a pilot - then lower the end mill and cut in the normal fashion. With this approach the work can be traversed to permit the slot to be cut.



Otherwise with care taken not to make too deep a cut, end mills are just adequate in most cases, albeit slow, for the purposes of producing enclosed slots. If the slot required is long, then a short portion of this can be produced a few thou. at a time until deep enough. It will then be possible to produce the remainder of the slot taking deeper cuts, as the end mill will then be able to be fed into the slot from the end of that already produced.

At sizes of a 1/4 inch and below both end mills and slot drills can be purchased with threaded shanks. It is, though, probable on grounds of economy, that the small 1/4 inch parallel shank cutters will be purchased.

For the larger sizes it is acceptable to use the cutters to produce slots wider than the cutter being used, this being done by moving the table over and taking a second cut. This practice should be avoided for the smaller sizes and as a result it will be preferable to have the full range of these sizes available.

This creates the need for some seven cutters, but at about a third the price of other similar sized end/slot mills, the small parallel shank cutters are much more affordable. These smaller cutters are three flute and take the form of slot drills.

2. Method of workholding

It is very difficult to give hard and fast rules for work holding, as the variety of situations likely to be encountered is very large.

The first consideration should be to clamp the part direct to the table. Where this can be done, it has the benefit of



maximum rigidity and accuracy as there is no added component to lessen these factors. This is most likely to be acceptable for components with a large, flat footprint relative to height, which also require machining over only part of the top surface. A typical example of this can be seen in **photograph 3**.

Where this type of component requires machining over all, or almost all, of the upper surface, there are methods of holding such, to permit this. The clamps shown in the Winter 90/91 issue on page 28 are an excellent method. Here, though, we are going beyond milling for the beginner which is the intended scope of this article.

For smaller regular parts, without doubt,

clamping techniques could be employed (studs, nuts and bars, etc.). However, the probability is that this will not be the case and some other method adopted such as using toolmaker's clamps, as can be seen in the photograph.

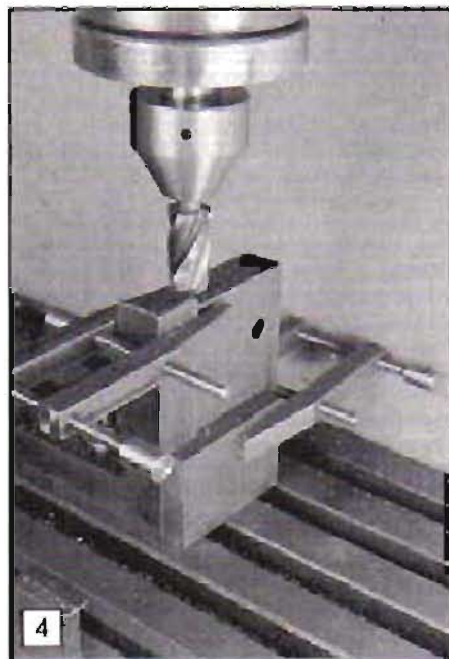
The first consideration should be, are there any holes in the component? If so, will these allow it to be fixed with screws passing through both it and the angle plate?

The most adaptable method, will be the use of substantial G clamps, or toolmaker's clamps. It cannot be stressed too much at this point though, the need for these to be correctly positioned and adjusted. Correct adjustment is particularly appropriate to the use of toolmaker's clamps.

The correct procedure for applying bar clamps was covered in the first part of this series, but the slight tilt of the bar as indicated there is definitely not appropriate to the toolmaker's clamp. This must be set such that both jaws are resting fully in contact along their length, both with the angle plate and the part being machined.

This can best be tested by trying to move the clamp from side to side when it is almost fully tightened. If in carrying out this test it tends to pivot on the end, then the clamp requires closing just a little at the centre screw, and the reverse if it pivots close to the centre screw. See **photograph 5**.

For the newcomer to toolmaker's clamps, it is essential to practice this procedure. To do this, hold a piece of flat steel in a bench vice and then tighten the clamp onto the portion projecting above the vice. Now carry out the above test repeating the procedure until it becomes fully understood and correct results easily achieved.



the vice is the accepted method providing its limitations as detailed in the first article in this series are taken into account.

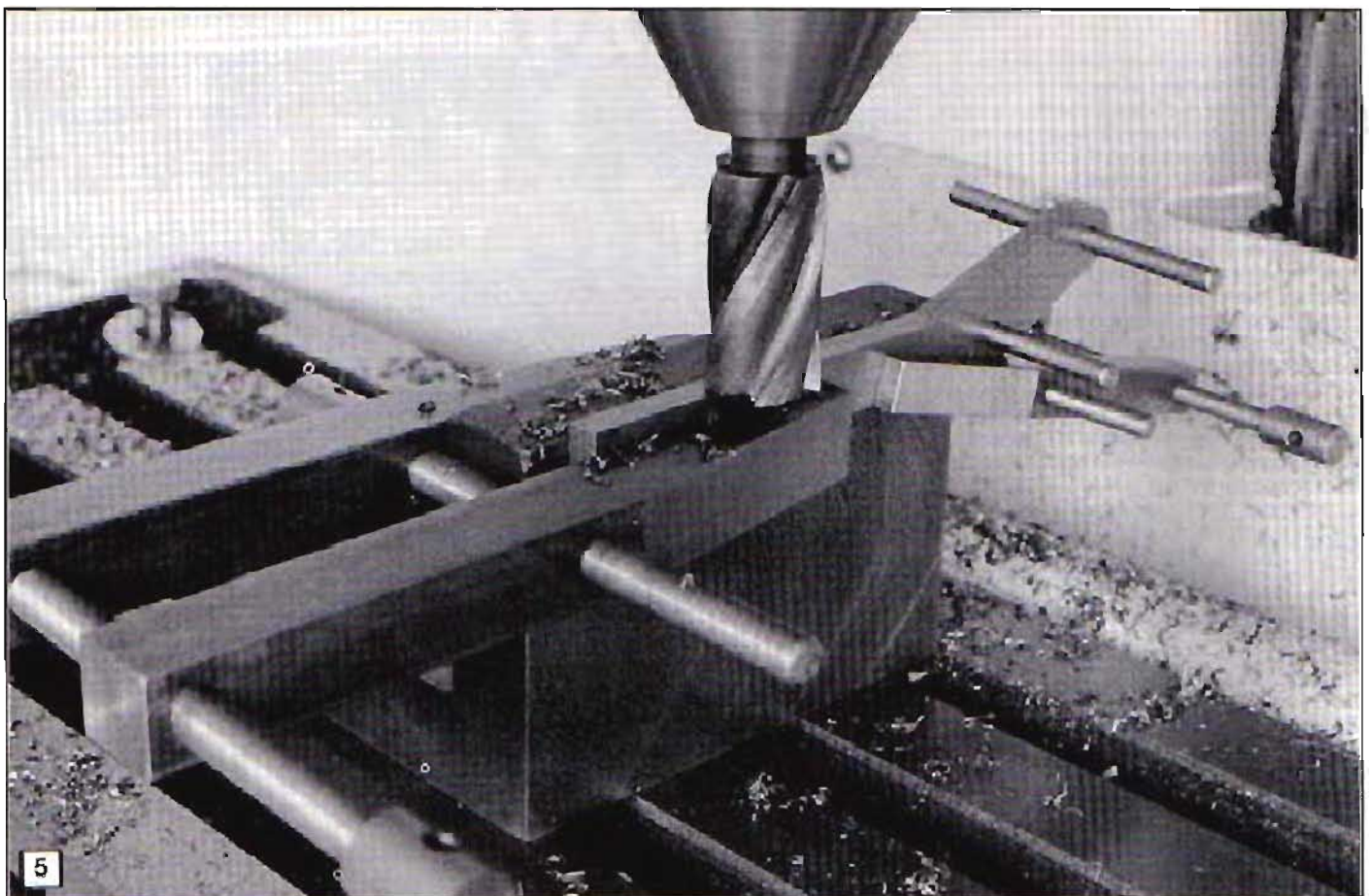
Parts with a small footprint relative to height are likely to be most suited to being mounted onto a 90 degree angle plate. A typical example of this can be seen in **photograph 4**.

This has similarities to clamping the component direct to the table and, if the part is small and the plate large, the same

3. Positioning the workholding device

Having chosen the cutter and the workholding device, the latter must be fixed to the table. This must be done with consideration to the basic requirements for milling, and also the demands of accuracy of the final component.

One requirement when milling is to consider the way the table is traversed relative to the way the actual cut is being taken. This is best considered in relation to horizontal milling where the problem



largely belongs. The purist will say it is also relevant to vertical milling and is probably correct when only light duty equipment is being used, typically a lathe cross slide.

When horizontal milling, the action is to pass the work under the cutter and there are two ways of approaching this. In the first method the work approaches the cutter in a manner that opposes its rotation. This produces the situation where the cut is taking place from a low level, moving to the top of the workpiece.

Alternatively, the work can approach from the other side. Here both the workpiece and the rotation of the cutter will be moving in the same direction and, the cut will be from the top of the work moving to a low level. Both these methods are

illustrated in **sketch 22**.

Considering the second method, it can be seen that the action of the cutter is to assist the movement of the table. Due to this and the relatively heavy cut applicable to horizontal milling, it is possible for this to suddenly move the table forward. This is possible as a result of it taking up the backlash in the leadscrew and the leadscrew thrust bearings.

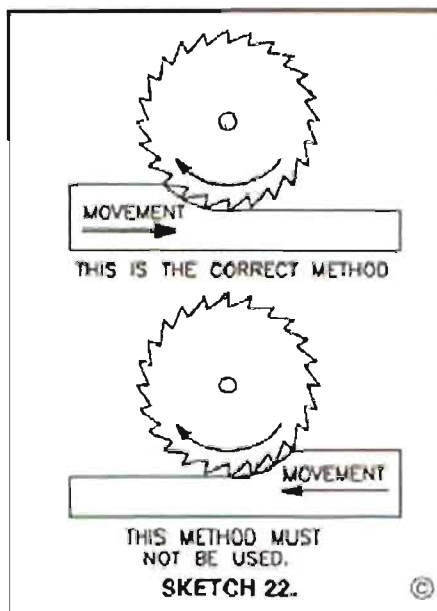
The resulting sudden increase in depth of cut can be very damaging to the part being machined, and even to the machine itself. Because of this, under no circumstances must this method be adopted. In the other method the cutter action opposed the movement of the slide, and the situation cannot arise. As a result, this is the method of working that should always be employed.

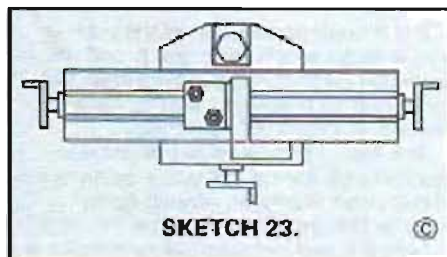
Another consideration, though less crucial in most cases, is still worth adopting. This is for the cut to be taken against the fixed member of the holding device. That is to say against the fixed jaw of the vice, or against the angle plate, rather than the clamping member.

Whilst these are essential working methods for horizontal milling, it is also a good policy to adopt these principles when using a vertical milling machine. It is of course true that in many instances the relatively light cuts taken when end milling will be incapable of moving the milling table. Even so, being aware of the problem will be beneficial so that it can be considered if, say, taking heavy cuts with a face mill. It will be more appropriate for those who carry out their milling operations on a much lighter lathe cross slide, or a very small milling machine.

Having decided on the general position for the workholding device, it is now required to position and fix it, with the degree of precision necessary. In the case

of the angle plate, positioning this with the degree of accuracy adequate for most operations is quite easy. The method is to use a square, the bed of which is placed against the edge of the table, whilst the angle plate is placed against the blade. This can be seen in **sketch 23**.





If the face of the plate requires to run along the length of the table, it can be measured from the edge of the table using the depth measuring facility of a vernier. Quite good results can be achieved by using a long straight edge placed against the face and measured at its ends with a ruler, the longer straight edge will magnify any error.

With the angle plate positioned and fixed by these methods, a good degree of accuracy can easily be achieved. Where a higher degree of precision is necessary, then it must be set up using a dial test indicator. This is identical in principle to that shown in **photograph 6** showing a vice being positioned.

In the normal situation a vice will be fixed using tee nut and studs, these in the slots provided at the end of the vice. These slots will be a generous clearance on the stud, and allow the vice to take up a range of positions. In the simplest situation, where a component is to be held in a vice and then machined over its complete top surface, the vice can be randomly placed.

Unfortunately the vice most likely to be available will have no means of simply positioning it in the way the angle plate can. In view of this the only practical method is with a piece of rectangular strip, say 2 x 1/4 in., fixed in the vice and then positioned with a dial test indicator (**photograph 6**). This can be a time consuming method.

The vice positioning device detailed in the April/May '92 issue page 24, is well worth the time spent making it. This device, if carefully made, will give results adequate for all but the most critical applications. Its method of use is very similar to positioning an angle plate using a square.

4. Fix cutter in the machine

Having already chosen the type of cutter there is very little that can be said regarding fixing it to the machine. But rigidity is all important, so do ensure it is correctly fixed. For example, if you do use end mills with parallel shanks in a collet chuck, do not be tempted not to fully engage the shank into the chuck for extra reach, this is highly dangerous.

If similarly mounting a slitting saw on an arbor, do ensure this is fully inserted into the chuck and very firmly tightened.

5. Choosing the correct speed

Of all the aspects of metal working in the home workshop that cause uncertainty, that of choosing the correct speed is probably one of the greatest. It is doubtful if any home machinist has ever done any exhaustive tests to determine best speeds. As a result any tables published are almost certainly of industrial origin. Here the need will be to remove the metal as quickly as is possible. It will though take account of the fact that, if too fast, tools will rapidly

become blunt and require changing frequently thus being counter-productive.

Rather than trying to work to published tables of speed it is best to understand the major factors which effect their choice. It is always preferable to try to understand the principles behind any situation rather than working blindly to a set of fixed rules and values.

The conditions met by the average home machinist are unlikely to match those of the industrial situation. In the home workshop machines will frequently be less robust and, with the difficulty of sharpening end mills and the like, tools will often be less sharp.

Under these circumstances, observing the signs will be the best route to determine if the speed is correct. If a reasonable finish is being achieved, there is no visible or audible sign of the machine objecting, and no obvious excessive heating of the part and particularly the tool, then probably all is well.

The effect of incorrect speed will differ depending on whether it is too high or too low. If too high, excessive heat will be generated resulting in the cutter becoming blunt quicker than it should. Because of this higher speeds are permissible if a generous supply of coolant is applied to the cutter, rather than with a brush as is often the case.

If on the other hand the speed is too low then the problem is quite different. Consider a large end mill, say 1 inch diameter, running at relatively slow speed (say 200 RPM) and being fed slowly into the workpiece. If the feed is 0.005 inch per cutting edge, then at this diameter the cutter would be quite strong enough to withstand the stress placed upon it.

Now if replaced with a 1/2 inch diameter cutter it would be unable to cope with this situation and would most probably break. Trying to feed the work piece slower to reduce the feed per tooth to something the cutter could withstand, would be both tedious and difficult to maintain. The result would still probably be a broken cutter. To make the situation practical, the cutter speed would require to be increased so as to make it easily possible to feed the table at a rate per cutting edge acceptable to the cutter. Finish is also likely to suffer with the speed too low, if this results in too high a feed rate per cutting edge.

Peripheral speed

Having said that cutter speeds are best established by experience and to suit the particular situation, the absolute beginner will still need some basis on which to start experimenting. It should be obvious that, as a general rule, it is the peripheral speed rather than RPM which is important, and will be a constant value independent of cutter diameter.

With this understood it is easy to establish the requirement for differing size cutters. Typically let us consider a cutter of 1/2 inch diameter and running at 500 RPM. Now if a 1 inch diameter cutter is substituted (ie twice the size) 250 RPM would be appropriate (ie half the speed). Similarly, if the cutter is replaced with one 1/4 inch diameter (ie half the size) the speed should be 1000 RPM (ie twice the speed).

So far the question of material has not been discussed, and this, due to the wide range of materials, cannot be covered in detail. The following will though be a basis

for the beginning to start. The above figure of 500 RPM for a 1/2 inch diameter cutter can be taken as the value for use with mild steel. Now for brass and aluminium double these figures, whilst for cast iron and bronze halve them. These simple rules should be easy to remember.

Experience should eventually show that, with sharp cutters, a good supply of coolant and a robust machine and set up, it will be possible to increase these values.

Owners of the typical mill/drill will understand that whilst these have a quite wide range of speeds, changing from one speed to another can be a chore. This will result in a reluctance to make changes and will be especially so if the task about to be taken is of short duration, followed by a need to revert to the original speed.

Faced with such a situation it is understandable if the speed is not changed, and by this approach it will soon be learnt that frequently the speed is not so critical as one may have first been led to believe. Providing no attempt is made to use very small cutters including drills at slow speeds, and very large cutters such as fly cutters at high speeds, it will be found that there is much more latitude in between than probably has been envisaged.

Being an article for the beginner this explanation of cutter speeds is a simplification of the actual situation, and some may say leaves out relevant information. It is though, true to say that if these principles are worked to no major errors will be made. Why add information which will only serve to complicate the situation, if it does not materially effect the final result to any great extent?

6 Position workpiece relative to the cutter

Having arrived at the situation where the part is now on the machine table, and been done with due consideration to rigidity and accuracy, it still remains to consider the position of the cutter with respect to the workpiece.

This may require to be established for any or all of the three axis. Ignoring the down feed axis which in any case is usually the easiest to deal with, the requirement can be divided into three situations as follows.

- 1) Where the position is of no importance.
- 2) Where the position can be established after machining has commenced.
- 3) Where the position is critical prior to machining.

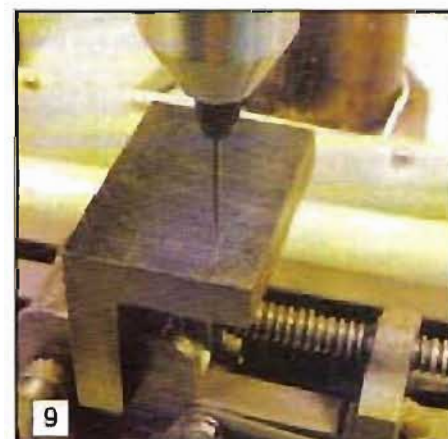
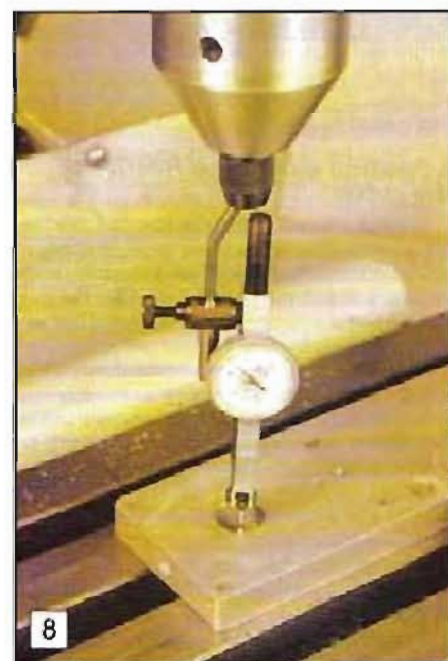
Typical of the first situation is the requirement to surface the complete top of an item mounted on the table or in a vice. In this case no reference will require to be made to the table leadscrew dials, just pass the workpiece under the cutter.

The second situation is the one which will be the most frequently met, and really presents very little problem. A simple example of this would be a length of square material mounted in the vice, being required to be milled along one edge to create an angle. Here the milling can commence and the part measured as the web of the angle approaches the correct size. From this measurement the depth of the final cuts can be established.

By far the most complex situation is where the position is critical prior to the machining commencing. A typical example of this would be where a slot has to be made in a rectangular component where its

position is important with regard to the external faces of the material. In this case the position of the external faces must be established and then the table moved accordingly, maybe in two planes, using the leadscrew dials to position the cutter correctly.

The methods of doing this were thoroughly covered in the article on edge finding, on page 22 of the Oct/Nov 91 issue. Also on page 45 of the Dec 91/Jan 92 issue the use and construction of an edge finder was published. In view of these recent articles the subject will not be expanded



upon here.

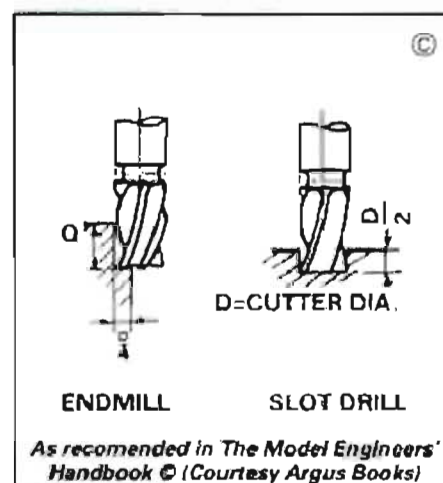
The use of an edge finder to locate the edge of a plate mounted on the machine table can be seen in **photograph 7**. **Photograph 8** shows the dial test indicator being used to position the machine spindle exactly concentric with an existing hole, whilst **photograph 9** shows the centre finder point accessory being used to position the spindle above a scribed cross on a component to be machined.

The methods shown in **photographs 7 and 8** will be capable of positioning to within a thou. or two. That indicated in **photograph 9** will be in the region of five thou. In all cases the degree of accuracy required will have to be considered in determining the method of positioning used.

The examples given above are just a few from a very large number of possibilities, far too many to consider here. Each situation will require to be analysed in line with the above brief suggestions.

7. Width and depth of cut

Having finally arrived at the point where machining is to commence, it is now required to decide at what rate material is removed. This will be dependent on the depth and width of cut, and rate of feed. In the excellent *Model Engineers' Handbook* by Tubal Cain (Argus Books, price £6.95 plus 70p p&p), it is suggested that, when cutting a step using an end mill, a suitable size of step would be for the depth of the step to be equal to the cutter diameter. Also for its width to be equal to one quarter



of its diameter.

I must confess that I never get anywhere near a depth of cut equal to cutter diameter. Rarely do I approach half cutter diameter – perhaps I should be more adventurous. This leads me to say that this aspect of milling is very much a case of building up experience and therefore confidence.

In the home workshop the question of production times does not take on the same importance as in industry. Even so, no-one likes to take longer than is necessary, so it really is a case of start by taking reasonably light cuts, then with experience gained over a period of time the rate of metal removal can be increased. The rate should be increased until a point is reached where that being done seems both right for the machine, and right for the

workpiece.

It is though possible to set the cut too fine, unless a tool is razor sharp, and the probability is that this is not the case. So for all normal machining aim to make the final cut at least 0.005 inch deep.

The *Model Engineers Handbook* also recommends for the slot drill a depth of cut of half cutter diameter. I would again suggest that perhaps rather less than this is initially set, and increased as experience is gained.

Conclusions

Using a milling machine successfully will very much depend on gaining experience over a wide range of milling operations. It is hoped that the basic information contained in this article will give you the confidence to get started.

The knowledgeable will no doubt say that much still remains to be said, and that in fact some suggestions are not exactly ideal. This may be the case, but the article has been established with simplicity in mind. In view of this once the user of the machine has become reasonably confident, further reading at a more detailed level should be undertaken.

Whilst titled *Milling Operations in the Lathe* this book, written by Tubal Cain and published by Argus Books price £6.50 plus 70p p&p, has some very detailed explanations of the milling operation in general. It is therefore well worth reading by anyone carrying out milling by any method.

To conclude, do remember that milling can be a dangerous operation, therefore take all necessary precautions. Make sure that both workpiece and cutters are very firmly fixed. Work with a guard wherever possible, with a little thought in design these are not so inconvenient as may be considered. (To be included in a future article. Ed.)

Milling in the lathe

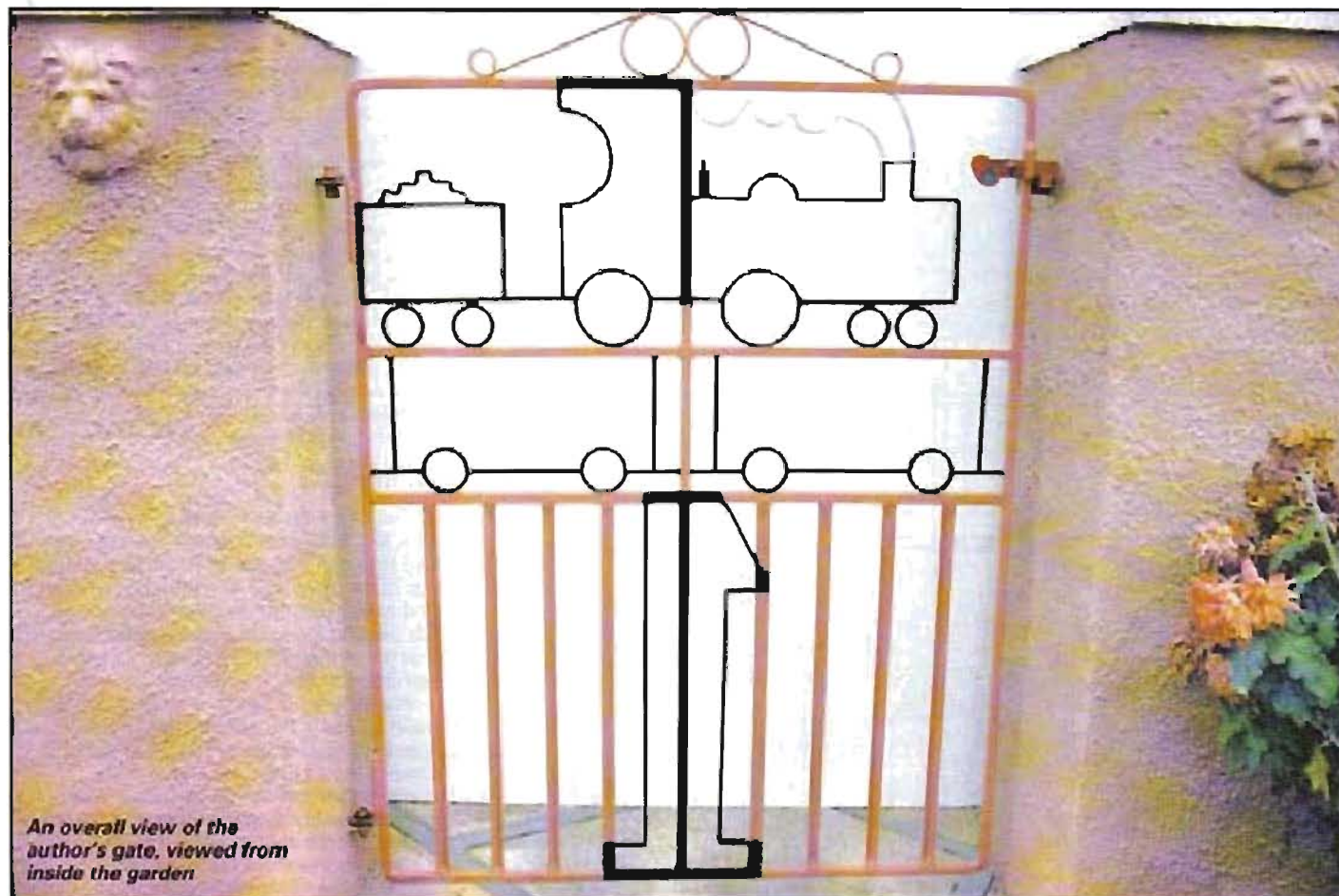
This series originally started as a three part article; it has since been decided to include a fourth part to include milling in the lathe.

This will not include milling using an add-on milling head as this only creates a situation very similar to a very small vertical milling machine and is covered largely by what has already been said. It will include milling with the cutters predominantly attached to the lathe mandrel, by some means or other, and using the add-on vertical slide where appropriate.

Other articles/publications

Copies of articles previously published and mentioned above can be obtained, £1.50 for UK readers and £2.00 overseas readers. Requests should be sent to the Photocopy Service, Argus Specialist Publications, Boundary Way, Hemel Hempstead, Herts HP2 7ST.
Copies of *Model Engineers' Handbook* Price £6.95. P&P 70p.
Copies of *Milling Operations in the Lathe* Price £6.50. P&P 70p.
Both from Argus Books, Argus House, Boundary Way, Hemel Hempstead HP2 7ST.

Cheques payable to Argus Books.



An overall view of the author's gate, viewed from inside the garden

A GARDEN GATE

In this garden gate we have a novel project provided by Sid Reid. This is an admirable chance to try out your new found skills, gained from the article on welding to be found elsewhere in this issue.

Being surprised at the construction and high price of garden gates traditionally designed, I decided to try something a little more adventurous, and offer the following for your amusement ...

The main frame, centre upright, and two cross members, are $\frac{1}{2}$ in. square M.S. positioned by centre drilling their ends, and inserting small studs, (bits of nails) which locate into pre-drilled positioning holes, prior to welding. A simple jig can be made out of round bar recessed to fit over the square M.S. and centre drilled for the size of stud. The gate corner were easily formed by heating the bar evenly with a propane torch and easing the metal round squarely.

The main problem with the $\frac{1}{2}$ x $\frac{1}{2}$ in. flat iron was holding the pieces in place, prior to light electric welding. This was overcome by cutting tees, or tenons in their ends, inserting them in locating holes and, if part of the construction riveting over. If you make one of the trucks, there are six joints, and four inserts into the $\frac{1}{2}$ in. square main framework.

A touch of "pi-dee" plus one thickness of metal (mean dia.) gives the length of strap iron to form a wheel and a $3\frac{1}{2}$ in. l/d



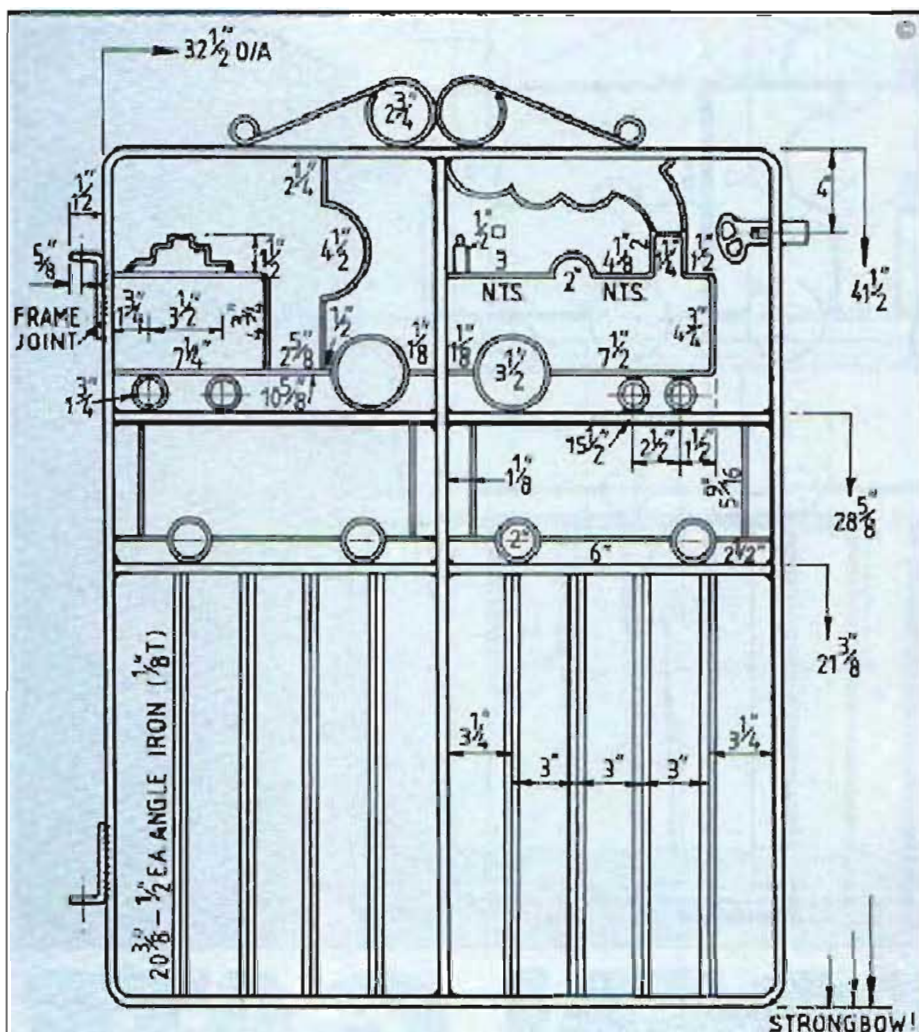
A close-up of the "signal" handle. The aspect glasses were made from plastic crystals.

wheel is given as an example, i.e. $\pi(3\frac{1}{2}$ in. + $\frac{1}{2}$ in.) = π x 3.625 in. = 11.38 in. say $11\frac{1}{2}$ in + 2 = $5\frac{1}{2}$ in., it is drilled and c/sk centrally (c/sk inside wheel) and fixed to a 4BA tapped hole in the crossframe. Tender and bogie wheels are drilled and riveted to the sub-assemblies. The bottom angles are held in place against the locating studs with a G clamp and a piece of flat iron pressing it against the stud.

An oven baked recipe

The catchplate striking angle is critical, and this one works like a dream, and is

riveted onto the backstop as shown, this in turn can be modified for backplate fixing. The signal pivots on a $\frac{1}{2}$ in. BSW mushroom headed screw, nut looked at the back, its **Rest stop** is placed over the signal, and



THE GATE - GENERAL ARRANGEMENT

QUICK TIP

Bolts or set screws used for clamping are subjected to a great deal of pressure on the ends. The pressure is similar to that which will mushroom the head of a punch or chisel. The reason why it isn't noticed is because it is a steady pressure, while a punch or chisel is hammered.

Full threaded bolts or screws used in toolposts and lathe carriers and similar applications are most at risk. In time it will be impossible to unscrew them when they need replacing because the threads will have spread on the end.

When you have half an hour or so free, check all the bolts and screws used for clamping and if they are threaded right to the ends, turn spigots on them.

The spigot should be about 1/4 times the diameter long and turned down till the thread has gone and then a bit more. Chamfer the end to break the burr.

Bolts and screws modified like this will last longer and unscrew when you want them to.

Where they are used on toolposts, to protect the bolts even more, a packer of aluminium, copper or Tufnol on the top of the tool will make a cushion, stop the tendency to spread and protect the tool shanks. Clamping a piece of thick card between the packer and tool shank will sometimes damp out the vibration which causes chatter.

R.J. Loader

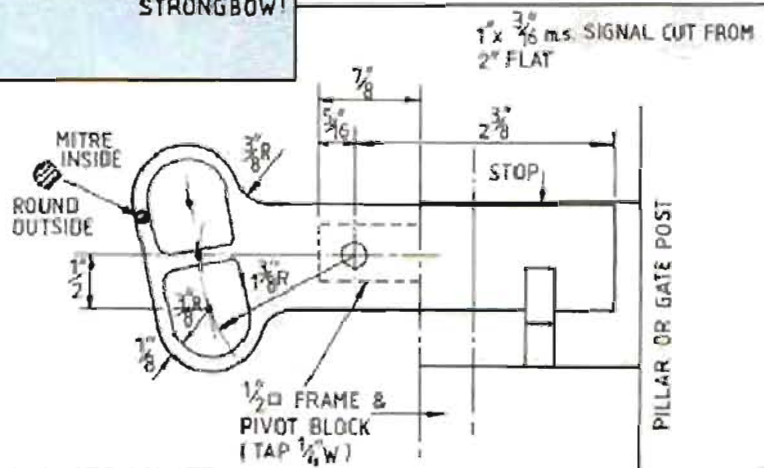
clamped to the frame ensuring the signal is horizontal, then welded to the frame. I had a game with the aspect glasses trying to melt coloured glass, my propane burner got it plastic, but it would not melt. Aspect you will find the solution far easier, and this was to use a Makit & Bakit "stained glass" kit, with plastic cooking crystals. Place the signal on a cookie sheet which has been covered with aluminium foil. Using a teaspoon and tweezers fill the aspects, heaped at the centre, level at the edges. Place in pre-heated 375 deg. oven, until crystals have melted to a smooth glass like finish (15-20 mins.), remove from oven, allow to cool, peel off foil. It was quite easy to file the mitres which hold the crystals ...

Fittings

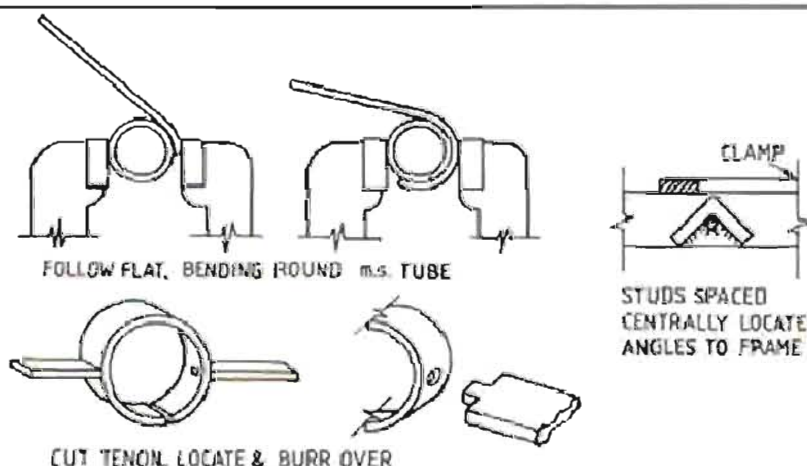
The hinges are 4 in. x 1 1/4 in. bent out of 1 in. x 1/4 in. M.S. drilled for 1/4 in. pivot bolts, end rounded 1 in. x 1/4 in. straps also drilled and cemented into the pillar brickwork.

Locate the gate, then the gate stop so that the signal sits horizontal in its groove, cement, and Bob's your uncle.

Points arising: The gate as drawn is left hand opening, the photo's right hand spacing between the bottom angles is close to stop pussycats, I left out the number **ONE** for obvious reasons. The crystals can be obtained from most good model or craft shops, and the signal latch is well worth the effort in the making. The welding was carried out with a domestic Topweld 140 plant, but I did go to evening classes to get the experience (good idea -



THE "SIGNAL" LATCH PLATE



METHOD OF FORMING WHEEL OUTLINES

TRADE COUNTER

A first look at products which may be new to you, plus information on finding difficult items and a few problem items to source.



New small 3 phase converter

N.D. Electrical have recently introduced a 1HP three phase converter which should be ideal for the average model maker. In the February/March 1992 issue of *Model Engineer's Workshop* the use of these converters was described in detail. When the original article was written, only a 2HP converter was available and it was found in practice that a "no load" motor running in parallel was almost essential when using the unit to run only a 1/4 or 1/2 HP motor fitted to a machine tool. Otherwise even on the lowest setting (number one), the motor was inclined to run "rough" due to the voltages between the three phases being high and uneven. The chance to try the new 1HP model was therefore welcomed. The first improvement to be seen was a set of display lights indicated when each of the

three phases and the boost (now called turbo) were operating. Due to the quiet operation of these converters, there had previously been a risk of leaving the unit on after a session in the workshop. The warning lights substantially reduce this danger. The unit was then tried with the "no load" motor disconnected. In all cases the machine tools could be started without difficulty and ran evenly. This was confirmed by voltage readings. It was however necessary to use the turbo switch to start the lathe under load. This could be inconvenient if the converter and machine tool were not adjacent to each other. The experiments were then repeated with the 1/2 HP "no load" motor reconnected. In this case easy starting and running was achieved, with all the machine tools without the need of the turbo control. The advice contained in the original article to use a "no load" motor where heavy starting techniques are likely to be encountered is still valid. At a cost of £129 plus VAT this new 1HP converter is still powerful enough to run any machine tool likely to be encountered in the home workshop. This price represents good value for money and may make 3 phase conversion a viable option for some model engineers. Further details from N.D. Electrical 29-35, Holly Rd, Twickenham, Middlesex, TW1 4EA. Tel 081-892-2722. Fax 081-744-1234.

Permanent Magnetic Positioners

Holding parts in position whilst welding can present quite a problem for the welder. Using these magnetic positioners from the well known magnet supply company Eclipse Magnetics will considerably ease the problem in most cases.

Details can be obtained from Eclipse Magnetics Ltd Unit 1-4 Vulcan Road, Sheffield S9 1EW. (0742) 560600.

Local suppliers of raw materials.

It is obvious that readers are looking for local suppliers of raw materials, where they can call and purchase small amounts, particularly larger sizes. This should preferably be without a minimum order charge or at least a low minimum order charge, say £5.00. Here is one supplier who fits this requirement: W.L. Cooke, Wangey Road, Chadwell Heath, Essex, RM16 4BW. (081 590 3279).

Frost Auto Restoration Techniques Ltd

A new catalogue is available. Send your request to Frost Auto Restoration Techniques Ltd Crawford Street Rochdale OL16 5NU. (0706) 58619. Enclose 24p stamp for postage, if you mention *M.E.W.* the catalogue is free.

Machine Mart Ltd

And still there's more. Machine Mart have opened their 26th store, this is at East Marsh Street, Grimsby. A free 116 page catalogue can be obtained, ring 0602 411200.

Square silver steel

I have received this offer of help in obtaining sq. silver steel from AmbleCraft. We have now published a number of suppliers for this material, but their list of surplus materials is worth obtaining.

I have just caught up with the April/May *M.E.W.* and noticed the item on square silver steel in the "sources of supply" column of "Trade Counter". Although the majority of our (part time) business is in the custom building of model railway rolling stock in the smaller scales, we do indulge in some heavier engineering, making workshop tools and equipment. We generally buy our metal in 10ft. lengths and where we have a surplus we offer it for sale in lengths and at prices attractive to the model engineer. Our policy is not to keep large stocks of metal but where we have surplus material we will supply anything between 3in. and 24in. (at the same cost per unit length) with no charge for single cuts off the parent stock (multiple cuts in thick bars might attract an extra charge), with postage at cost - payment in advance as per our pro-forma invoice. We have no credit card facility.

If your readers have difficulty in obtaining square silver steel in the lengths they require (whether that be shorter or longer than the standard 13in.) we would be interested to hear from them to assess whether or not it would be worthwhile us holding a small stock of material (say 1/2in., 1in., 1 1/2in., and 2in.) to serve the needs of model engineers. Responses accompanied by an S.A.E. will (after a few weeks delay to assess the responses) receive our current list of surplus materials and information on whether or not we will be able to supply square silver steel.

AmbleCraft, Precision Model Engineering, 75 Blenheim Road, Horsham, West Sussex, RH12 5AQ. Tel. (0403) 58548; 6pm to 10pm.

New items for the Hobbymat and Universal Bender

C.Z. Scientific have announced two long overdue additions to their range of products for the model engineer.

First and most important for the numerous users of the Universal metal-bender is a sturdy plastic carry-case with moulded inner. The illustration clearly shows the neat arrangement of the bender components in the case. No longer will you waste valuable time searching for the smallest pin or the 6mm grooved roller. Priced at £7.50 plus VAT, the cases will be available through your local dealer and from Rymail Ltd.

The second article will be welcomed by all users of the Hobbymat BFE 65 Mill/Drill. C.Z. are introducing a matching cover, in Hobbymat yellow, in response to popular demand. The cover will be available from your local dealer at the price of £8.59 plus VAT.

For further details, please contact: Hobbymat Department, C.Z. Scientific Instruments Ltd, 1, Elstree Way, Borehamwood, Herts WD6 1NH. Tel: 081 953 1688. Fax: 081 953 9456.





E951 Magnetic Quick Clamp

Designed to enable fast and accurate holding of ferrous metals for welding and assembly jobs. It will hold both sheet and tube at angles of 180°, 90°, 75°, 60°, 45° and 30°. Magnetic quick clamps are usually dispatched with paint all over. The magnetic pull can be increased to 25kg if the painted edges are finished, or ground smooth and parallel. E953 - More stability and better performance through air gaps.

Catalogue No.	Dimension mm	Pull kg
E951	100x65x12	15
E953	100x65x21	10

E920 Magnetic Adjustable link

The Eclipse magnetic adjustable link is a twin unit possessing a multi-angle capability. It can be quickly locked at any angle by the turn of a wing nut. By using the links in multiple, the most complex arrangement of sheets and strips can be firmly and easily secured for welding.

Being compact in size they are ideal for holding work in confined spaces. Blocks can also be used singly as the basis for jigs.

Catalogue No.	Dimensions of each block mm	Overall length mm	Overall width mm
E920	60x25x29	127	51
E920SU	Single Unit-No link		

E952 Magnetic Variable Clamp

An adjustable magnetic clamp for quick and accurate holding of ferrous sheet and tube for welding and assembly jobs. It is infinitely variable from 25° to 280° enabling any angle within this range to be set and copied. The main angles of 90°, 60°, 45° and 30° are marked for quick reference.

Catalogue No.	Dimensions (mm) (arms at 90°)	Pull kg
E95	2195x200x11	20

Sources of supply

I would like to thank numerous readers who have provided the following information, too many names to detail. These are in reply to requests for materials and tool suppliers in previous issues.

1) SRBP/F (Synthetic Resin Bonded Paper/Fabric) and similar, frequently known as Paxolin, Tufnol etc.

D A Wilkins Unit 001, Solent Business Centre, Southampton, SO1 0HW.
College Engineering Supply Co. 2 Sandy Lane, Godsall, Wolverhampton, WV8 1EJ.
09074 2284.

2) Ebonite. No replies yet, can any reader help?

3) Stainless Steel, square and hexagon sections. G.L.R. Distributors Ltd. Great Northern Works, Hartham Lane, Hertford,

SG14 1QN. 0992 552962 (Hex). Flapstock Ltd. Shucklow Building, Little Horwood, Milton Keynes, MK17 0PT (029671 3631)

4) Soft Iron for electro magnets. No replies yet, can any reader help?

5) Second hand electric motors: Fan and Motor Centre. 65 Sidney Street, London E1 2EV. (071 247 3710) Send stamp for list.

6) A company who will sharpen milling cutters and the like: Merlin Engineering, Unit 6, Horris Trading Estate, Bromyard Road, Tenbury Wells, Worcestershire, P and M Reprints, Unit 9, Britannia Industrial Park, Dashwood Avenue, High Wycombe, Bucks. HP12 3ES.

R.F.C. 38 School Close, Gamlingay, Sandy, Beds, SG19 3JY (0767) 721864. D. Edwards (Shropshire) Phone 058 472 406 evenings.

Some new requirements

1) Tin Plate of about 24swg or 0.5mm (material from oil cans is too thin. Is there a supplier who can supply small sheets, say 500mm sq, or maybe a user who would be willing to make available pieces from their scrap bin?

2) Electro Plating Materials.

3) Company willing to carry out electro plating in small quantities.

4) Shield glasses for MIG welding.

5) Half round brass strip (A.J. Reeves & Co (B'ham) Ltd Holly Lane, Marston Green, Birmingham, B37 7AW Tel 021-779-6831-3. Stock this in 1/8, 1/4, 3/8, 1/2 and 3/4 in. sizes, prices on application).

Can anyone else help with information on sources of supply for these items?

I will be pleased to publish names of similar local suppliers if readers will send in details.

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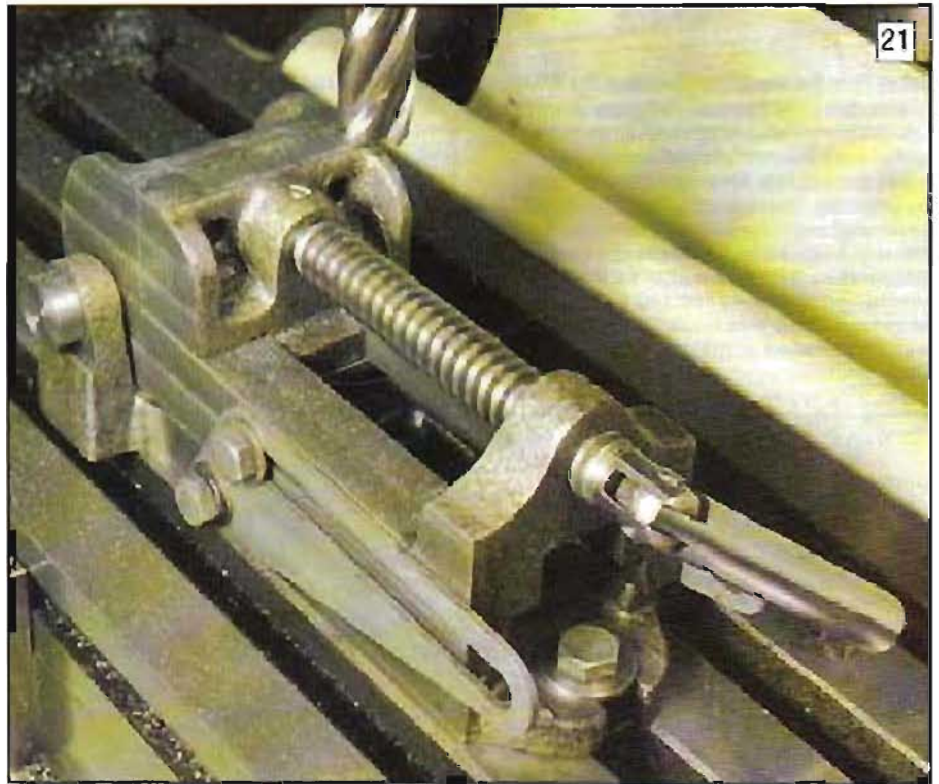
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Whilst some tilting vices supplied are of excellent quality others are little better than a set of part machined castings; as they stand are not much use for the sort of precision machining that we wish to achieve. This article aims at improving a poor example of this type of vice to acceptable standards. Written and illustrated with the beginner in mind, it will form an excellent exercise in its own right. It is worth reading even if the work is not to be undertaken, as several of the set-ups used will be useful in other operations.



IMPROVING A MILLING VICE

Having one of the tilting vices typical of those supplied with most mill drills, it soon became apparent that it had some shortcomings, the most important being very poor construction with regard to the moving jaw keep plate. This was very short and, additionally, had too much clearance over the sliding faces. These together permitted the jaw to lift considerably.

The problem was compounded by the fact that the machined face on which the keep plate slid did not reach the end of the keep plate's travel. As a result the problem was even worse at the ends. The reason for this was that this surface of the casting tapered away at each end.

In addition to the problem with the jaw, the overall accuracy was poor as was its appearance. The vices presently offered for sale do outwardly appear of better quality; whether this is translated into accuracy I have no knowledge. There will be, though, many earlier vices which will benefit by the attention proposed in this article.

These vices in no way compare with the much more robust and as a result much more expensive milling vices. They are though quite adequate for a range of milling operations, that is, if the shortcomings can be largely eliminated.

In view of its shortcomings, overcoming these was considered. First it would be essential that the problem of jaw lift was considerably reduced; if not, any other work on the vice would be of little purpose.

Making a true sliding surface

Highest priority was therefore to improve the face on which the keep plate moved. The absence of a machined face at the ends, due to the taper on the casting, could easily be corrected by machining a little deeper. There was plenty of thickness to the casting at this point, so a further say 1/8in. removed would extend the faces, without unduly weakening the vice.

A new, longer keep plate could easily be made and fitted which, together with the improved machined face, would considerably reduce the problem of jaw lift. Having decided that it would be possible to resolve this problem, generally improving the overall accuracy should be quite possible.

Stating that achieving a more accurate vice is possible does not mean that it is straightforward! The major problem stems from the fact that it is a tilting vice. As a result, many of the machining operations have to be carried out with reference to the hinge pin.

It would be easy to arrive at an adequate result in the horizontal position, only to find that the vice jaw is not parallel to the base when pivoted through ninety degrees, due to the appropriate procedures not being adopted.

The requirement for improving the vice also assumes that it may at some time be used without the base. In this case the

lower face of the vice must be machined to achieve accuracy when used in this manner. For the newcomer to milling, improving this type of vice will be a challenging project, and one from which much can be learned. For that reason the procedures are given step by step, both in the text and in the illustrations.

It is probable that the underside of the base will be satisfactory. This can be determined by first placing the complete vice on a surface plate, to determine if there is any rock present. The test can be double checked by testing with the thinnest feeler gauge available around the base.

If a surface plate is not available, then the milling machine table could be used as a substitute. Slight errors could be eliminated by the use of marking blue and scraping the base. I will not cover this in detail, but any reader not conversant with this method should refer to the Jun/Jul '91 issue, where this process was very adequately covered.

In the unlikely event of a large error being present, the underside will require lightly machining. This can be done by turning the vice upside down and clamping it, using its own jaws, onto an angle plate fixed to the milling machine table. Set the fixed jaw against the machined face of the angle plate. A piece of round bar between the moving jaw and the unmachined face of the angle plate will negate any inaccuracy due to the rough casting, or the jaw moving.

Support the handle end of the vice using a makeshift jack if you do not have a proper one. With the vice set up in this manner lightly machine the faces to arrive at a satisfactory result. This operation is not shown in the photographs, but all the remaining major stages are illustrated.

It should be added at this stage that the photographs were taken after all the machining operations had been completed, the reason being that originally there had been no intention of making an article from this project.

is probable that about 10 thou. will be machined from each. The hole in the base should therefore be lowered by a little under $\frac{1}{2}$ inch; this will also allow for the pin to be increased in diameter by $\frac{1}{2}$ inch. Of course, first check the vice to see if these figures are appropriate for the one being machined.

Now set up the base on the lathe cross slide as shown in **photograph 1**. It is essential that the packing chosen to bring the pivot hole to the correct level has parallel faces. This is to ensure that the pin

The latter benefits from greater rigidity, but then it becomes more difficult to test the hole diameter.

Providing light cuts are taken the method illustrated should prove satisfactory. This method also benefits from being easier to adjust the diameter, and therefore easier to arrive at the required diameter without unacceptable errors.

Continue to increase diameter until the plug gauge just enters the hole; test both uprights on the base.

With this completed satisfactorily, leave the boring tool in place in the chuck for the next operation, but remove the vice base from the lathe. Check using a surface plate and a dial gauge to see if the pin is parallel to the base. This can be seen in **photograph 2**.

Bore hole in vice

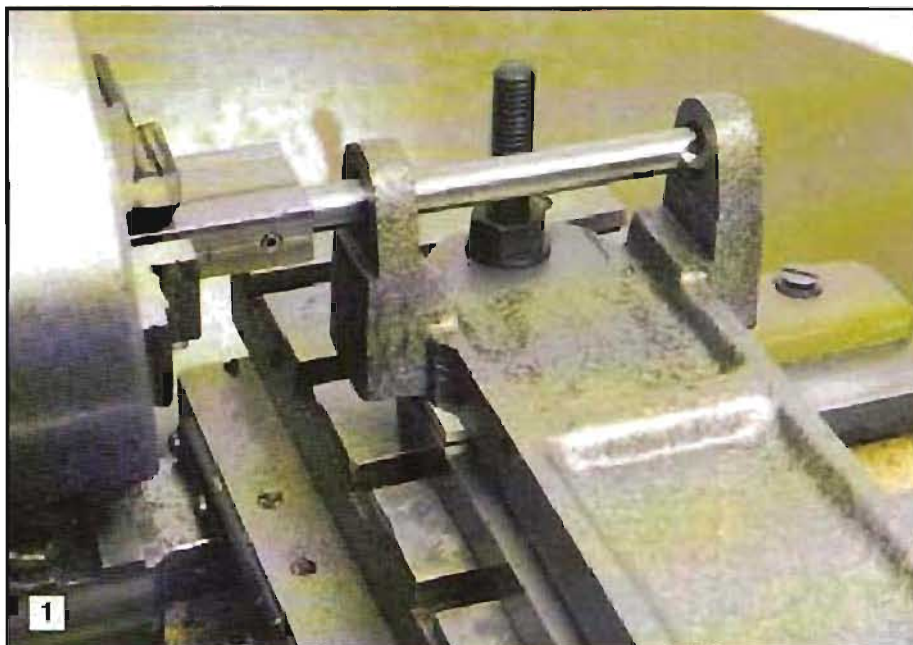
Now set up a small angle plate on the cross slide. Ensure the face is parallel with the axis of the lathe, using an engineer's square located off the side of the cross slide. This should be accurate enough, as the inside face of the vice will eventually be machined.

If a suitable small angle plate is not available, then a piece of square section metal could be clamped to the cross slide. This would have to be about 1 to $1\frac{1}{4}$ inch square.

With the vice upside down, clamp to the angle plate, and position at the correct level to bore the hole approximately concentric with the existing hole. Also make sure that the vice bottom is reasonably horizontal.

To check this, place a straight edge across the bottom of the vice and along the length of the lathe. Measure the distance between the bed of the lathe and the straight edge at both ends, adjust until both ends are reasonably equal. Absolute accuracy is not essential as errors will be machined out with subsequent operations.

Return the boring tool to a smaller diameter, and bore out the hole in the vice in stages as before, this is seen in



Bore a hole in the base

Before starting this actual operation some decisions have to be made. Almost all existing machined surfaces are to be re-machined and as a result the vice will rest lower at the handle end.

This would be due to machining both the underneath of the vice itself, and the pads at the handle end of the base, on which it rests. To overcome this, the pad could be raised by the addition of a pad, typically a large flat headed rivet. This approach was rejected in favour of lowering the pivot pin in the base.

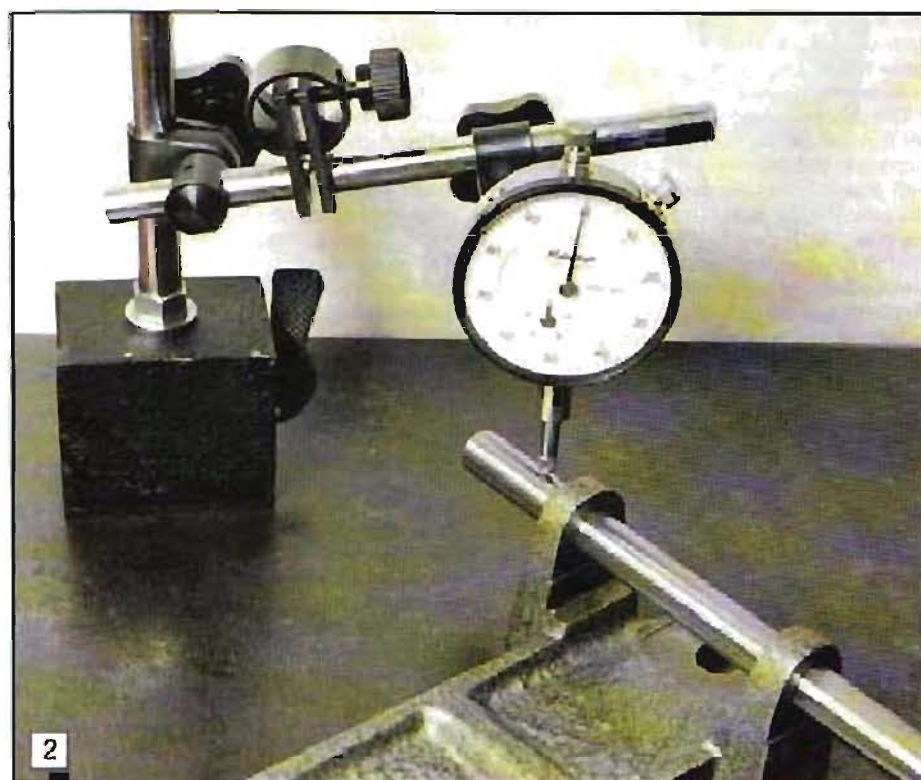
It had already been decided to open up the holes and fit a larger pin; lowering the hole added very little extra complication. The decision to increase the diameter was due to the existing pin not being a good fit.

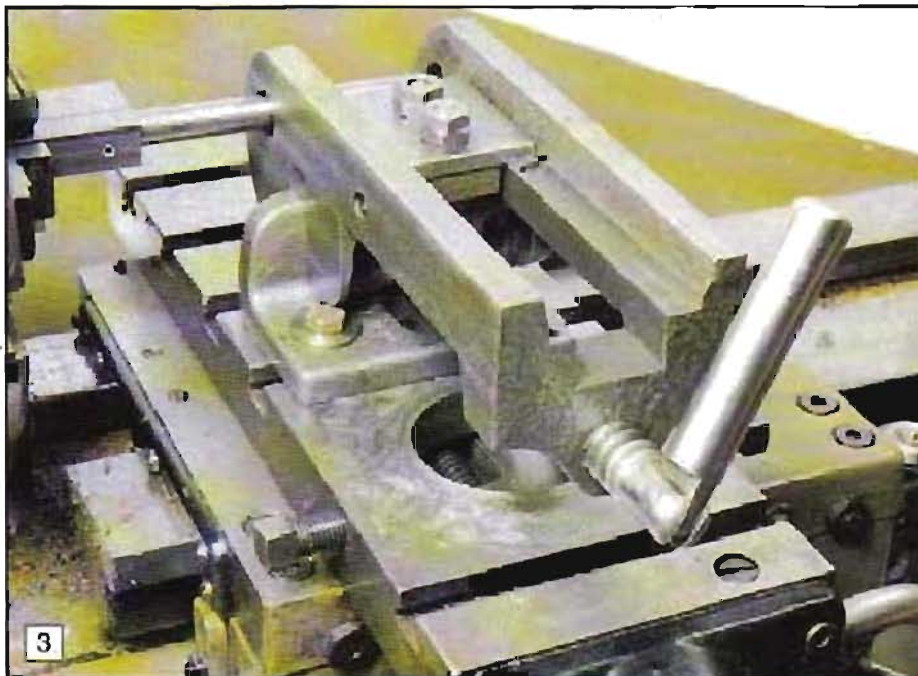
It will be required to place a long rod through the pivot holes on a number of occasions. This is so that the part can be checked with a dial test indicator to establish that it is correctly positioned on the machine table. In view of this, preferably choose a pin diameter for which a suitable rod is available. This will avoid having to turn a long length specially. If a reamer is also available at that diameter, ensuring the holes are a close fit will be easy. If a reamer is not available, then first turn a plug gauge to the required diameter. This will be used to test the bore to see if it is at the correct size. Make the gauge as is frequently advised, with one or maybe two steps at 5 thou. and 10 thou. undersize. These are used as early indication that the hole approaches its required size.

When machining the base of the vice itself, and also the pads on which it rests, it

will be parallel to the base. If it is not, the accuracy of the finished assembly will not be to the standard required.

The holes can be bored using a top slide boring tool, mounted in a four jaw chuck as shown. The four jaw chuck will enable adjustments to the hole diameter to be made easily. Alternatively, the hole can be bored with a boring bar between centres.

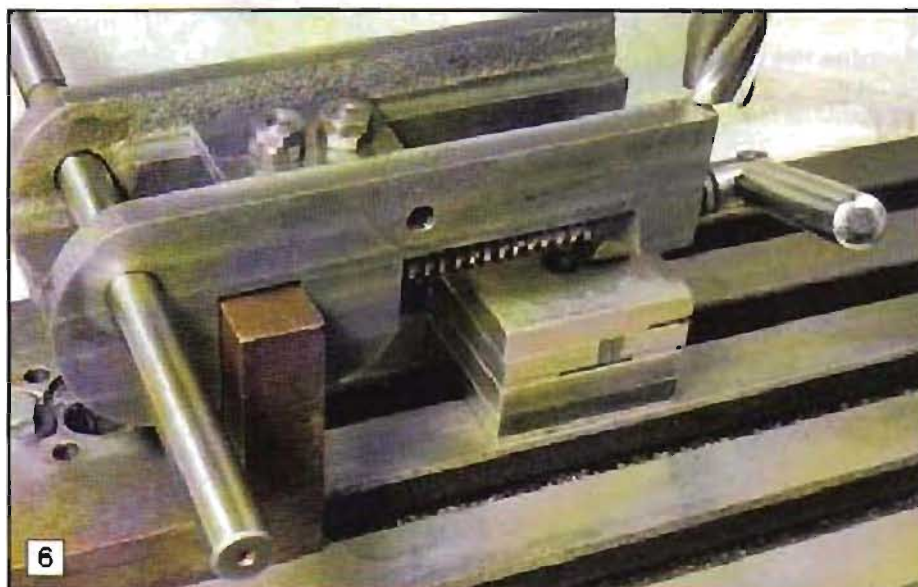
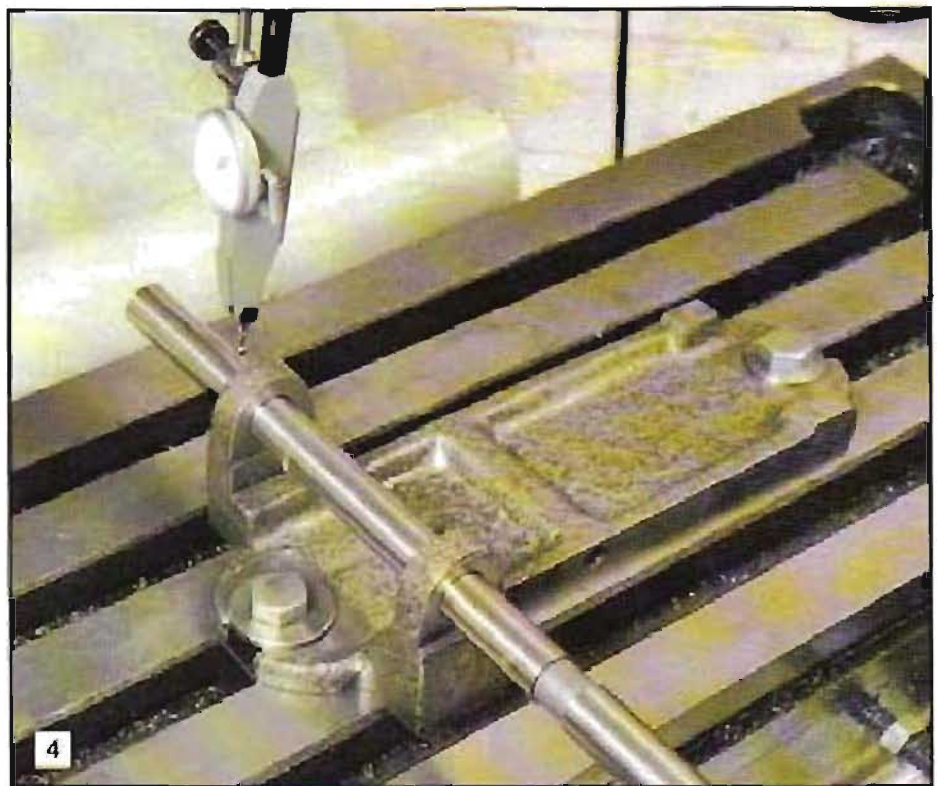
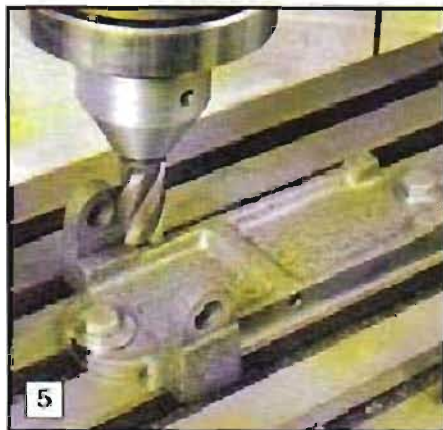




photograph 3. Use the plug gauge to establish when the hole is the correct size.

Machine base upright side faces

Machining now transfers to the milling machine. Set up the base on the milling machine table and, with the rod through the pivot hole, position this to be exactly parallel to the cross travel. Achieve this by testing the side of the rod at both ends, using a dial test indicator mounted from the machine spindle, as seen in **photograph 4**. Accuracy for this operation is essential.



With this done, machine all four sides of the uprights, **photograph 5**. Remove only just sufficient metal to create a true surface, dimensions are not critical.

Ensure that this face is created by starting at the top, and lowering the end mill in stages to produce the flat face. It is not acceptable practice to cut the full width of the face, using the side of the end mill at one pass. To avoid the end mill being fed in from the side, make sure that the appropriate slide is firmly locked.

Machine lower face of vice

Set up an angle plate on the milling machine table, absolute accuracy is not required. With the vice upside down clamp it to the angle plate. Place a rod through the pivot hole and test with a dial test indicator. Test on the top of the rod at both ends, and adjust vice until the rod is parallel to the machine table. Accuracy is very important for this setting.

Note the difference between this and the previous set up; in this case the indicator would be testing on top of the rod, whilst in the previous case the test was on its side.

Very gently support the overhanging end with a jack; do not distort the vice by this action. Machine the base of the vice taking light cuts only as can be seen in **photograph 6**. Remove just sufficient to be sure that the bottom has been fully machined.

Now take the vice apart completely for the following machining operations.

Machine top face of slide ways and fixed jaw face

Position the vice body on the machine table. Using a rod through the pivot pin hole, test with a dial test indicator and adjust until the pin is parallel to the slide cross travel. First machine the jaw face,

removing only just sufficient to achieve a satisfactory result. Again start at the top of the jaw and drop the end mill for successive cuts until the face has been fully machined, **photograph 7**. Lock the slide not being moved to reduce the possibility of the end mill cutting on its complete side face due to accidentally moving this slide. With the jaw face machined, stick onto this a piece of masking tape or similar. The purpose of this is to give an indication that the cutter is getting close when machining the slide ways.

Machine the slide way top surfaces until they have been fully machined. Remove the minimum amount necessary, very carefully machining up to the jaw face to get a square corner.

Machine keep plate slide ways

The next stage is to machine the faces on which the keep plate slides. These two



faces must be exactly parallel to the upper slide way faces and to achieve this the vice must be placed on some accurate parallels, as can be seen in **photograph 8**.

When in place on the parallels, clamp in position. As the vice overhangs the parallels do not over-tighten as this may distort the casting and cause errors in the final result. After machining the slide ways, remove the part and measure the slideway thickness with a micrometer to check that they are parallel, **photograph 9**. All should be well but if an error exists this must be corrected.

If the error is small, say up to 1 thou. over the length, this could be eliminated by scraping the face just machined in the appropriate position. Do not attempt to

correct by scraping the larger upper face.

In the case of a larger error, the reason for this should be established and the necessary action taken before remachining the keep plate slide ways. A satisfactory conclusion to this operation is vital.

It should be noted at this point that the faces between the two slide ways are the only machined surfaces that are not re-surfaced. This applies to the surfaces on both the vice body and jaw.

The reason for this is that, if these were machined, the jaw would then become loose and pivot excessively. A small amount of clearance will not be a problem and, as a result, the vice as supplied will probably be acceptable.

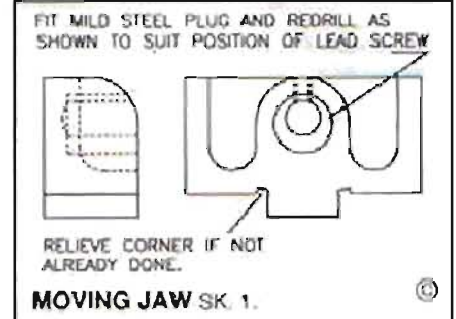
Machine the moving jaw's sliding surfaces

It should be found that the sliding faces are already relieved, that is milled slightly lower where the two faces meet at right angles. If not, this should be done using a small end mill. This operation will be easier if the jaw is set up on an angle plate and tilted very slightly to enable it to be carried out without fear of machining the side face. This can be seen in **sketch 1**.

Now set up the jaw on an angle plate using a parallel below the jaw to get it adequately positioned. A high degree of accuracy is not required at this stage.

First machine the two sliding faces. Do ensure both are at the same depth setting to ensure they will sit properly on the vice body slide ways, **photograph 10**.

Follow this by machining the top of the



central portion. Do this so that it is a few thou. lower than the thickness of the vice slide way measured previously. The studs showing in the photograph will of course have to be removed.

A close fit of the jaw to the main body can eventually be arrived at using shims between the jaw and keep plate, or alternatively by the use of adjusting nut and lock nut. The latter arrangement has been used for the vice illustrated in this article.



Keep plate and assembly

The original keep plate will probably have been fixed using fixing screws; these are to be replaced by studs. It is essential that the studs do not project below the bottom of the vice to ensure that the vice can be used without the base. Either wring in the studs tightly or fix them with a little suitable adhesive.

Make a new keep plate from $\frac{1}{4}$ in. thick steel and as long as can be accommodated. The length of stud available will probably not permit two normal nuts to be fitted to each to act as adjustment and lock nut. Therefore reduce the thickness of four nuts to suit. This can be seen in **photograph 11**.



Moving jaw leadscrew hole

As a result of machining the underside of the jaw and its mating surfaces, the hole in the jaw for the thrust end of the leadscrew will no longer line up with the leadscrew itself. It will therefore be required to raise this hole in the jaw. To do this, open up the existing hole and fill this with a plug of steel, using Loctite 601 or similar to fix it.

When set, this has to be drilled at the correct height to take the end of the leadscrew. The diameter of this plug will have to be sufficient for the hole to be drilled without breaking through its edge and into the jaw casting.

It will also be necessary to drill and tap through the existing hole and into the plug for the screw which makes the jaw captive to the leadscrew. Fitting the plug can be seen in **photograph 12**; this also reveals that the original position had a sideways error.



Machine the moving jaw face

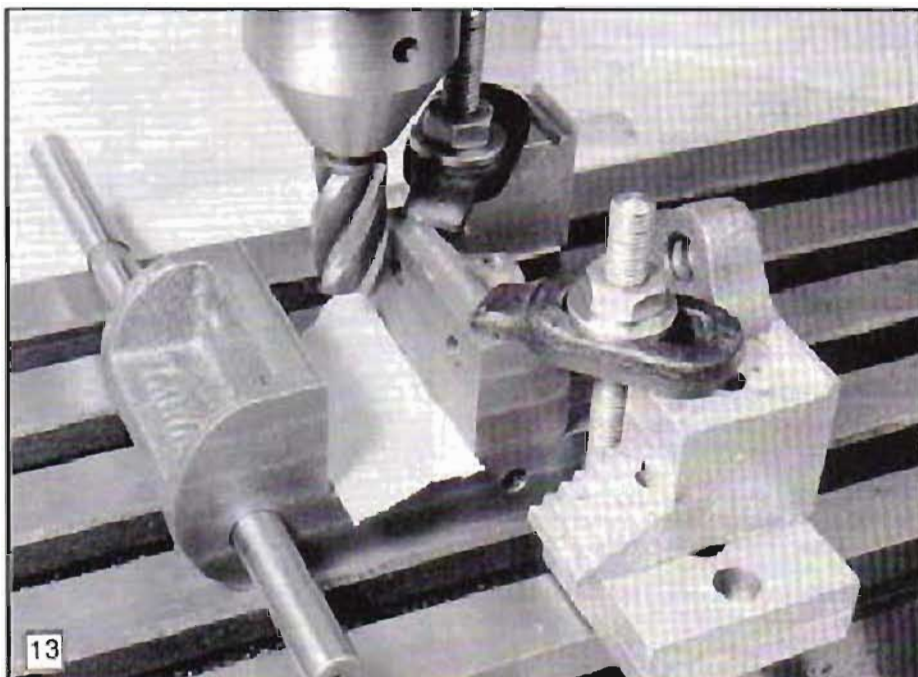
Fix the vice body to the machine table and line up using a rod through the pivot hole as previously done when machining the fixed jaw. Now rest the moving jaw between the two sides of the body and push the jaw to one side, against the inner surface of the vice body. Then carefully tighten the jaw as shown in **photograph 13**.

It is now time to machine the moving jaw face. Fix a piece of masking tape or similar to the vice body adjacent to the moving jaw. This will give indication that the end mill is close to this surface. It is absolutely essential that this is not touched by the end mill. Machine the jaw face in the same manner as was the fixed jaw.

Remove the jaw and, with a file, remove the slight projection left where the end mill did not reach fully the bottom of the jaw.

Machine first side

Remove the jaw and also the vice body from the machine. Fit the keep plate using one nut on each stud. Run the second nut onto each stud and lightly tighten onto the



first, adjust carefully until the jaw is just able to be slid along and finally lock the two nuts on each stud. Feed the leadscrew into the hole in the moving jaw and fit the leadscrew fixing screw.

Return the angle plate to the machine table, and position this square to the side of the table. A high degree of precision is not required. Clamp the vice using its own jaws onto the side of the angle plate and with its side just above the top of the angle plate.

It is now required to ensure that the base of the vice is accurately upright. This can be done using a precision square standing on the machine table (**photograph 14**). An alternative method would be with a dial test indicator mounted from the machine spindle. With this arrangement test both sides of the vice base by moving the indicator up and down using the downfeed handle. Adjust the position of the vice until



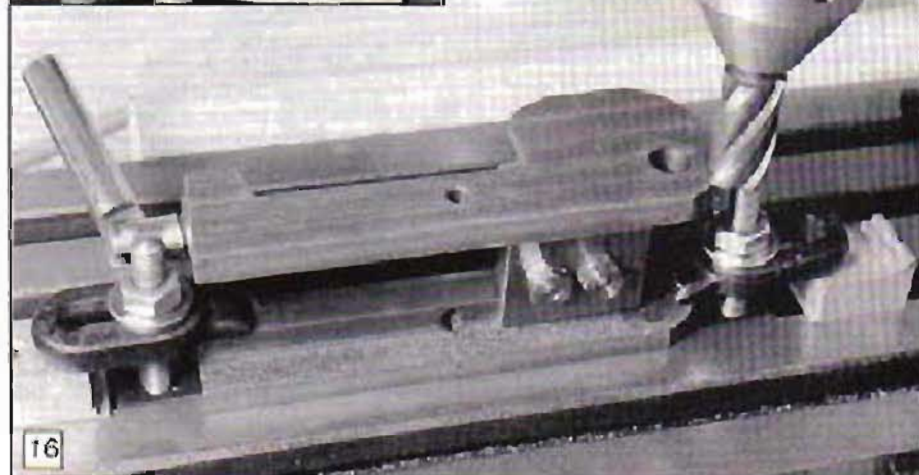
both sides read the same.

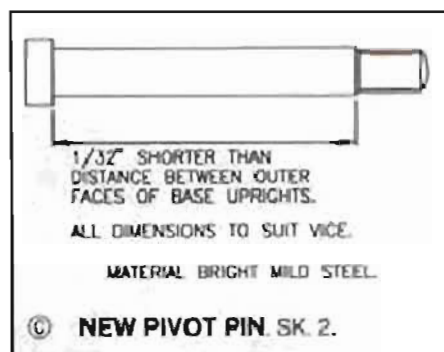
For maximum rigidity a tee nut with screw can be used as a jack as seen in **photograph 15**. It is essential though that this arrangement does not distort the casting, so very carefully adjust the jacking screw to only just touch the underside of the vice prior to tightening the associated clamp.

When the vice is accurately positioned, machine the complete side of the vice, including the jaw, removing the minimum necessary. Remove vice from angle plate and angle plate from machine table.

Machine second side

Close the vice lightly and place the newly machined side down on the machine table and clamp in position. Accurate positioning is not required for this operation. Lightly machine the second side can be seen in **photograph 16**.





Make hinge pin and washers

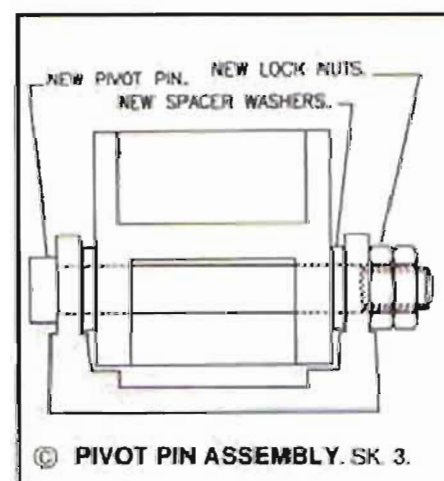
Return to the lathe and make the pivot pin as **sketch 2**. Measure the width of the vice accurately at the pivot pin end, also the distance between the inside faces of the uprights on the base. Subtract the width of the vice from the distance between the uprights and divide this value by two. Make two washers to this thickness dimension, with holes to go over the pivot pin.

If suitable nuts are not available to go on the end of the pivot pin, make two to suit. All the parts that need to be made can be seen in **photograph 17**.

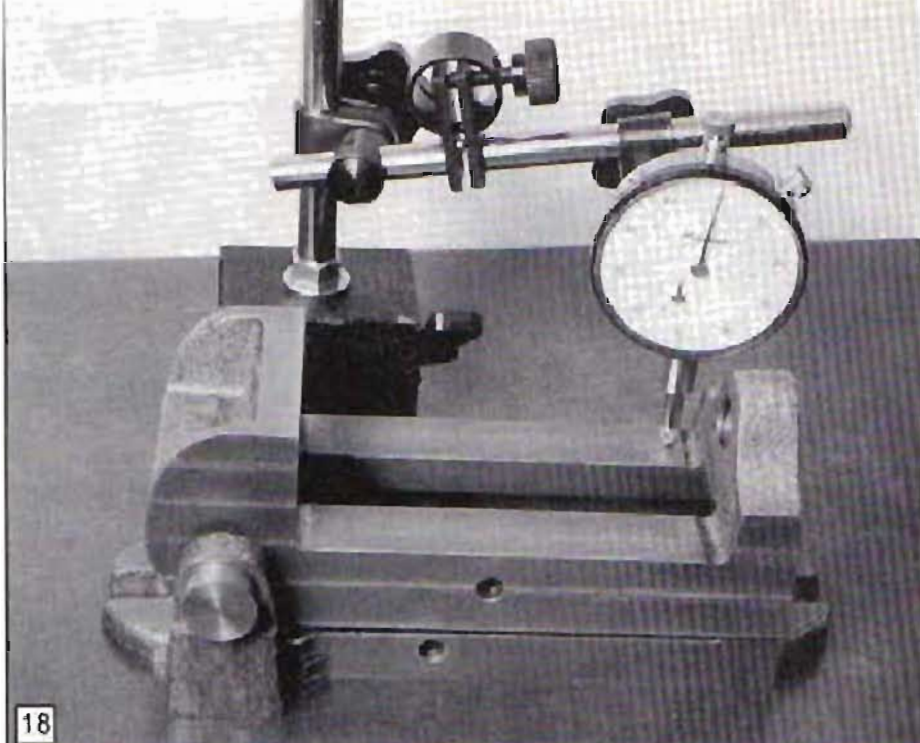


Assemble and measure slope

Remove the jaw and main screw and then assemble the vice body onto the base using the pin. Use one washer on either side between the vice and the base uprights. Fit two nuts, one locked onto the other, adjusted so that the pin has no end float but is free to rotate. See **sketch 3**. This ensures the assembly has not been over-tightened onto the uprights and distorted the base.



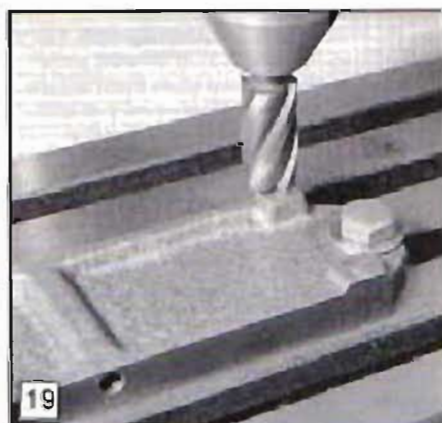
The vice will now have a small slope due to the hole for the pin having been lowered in the base uprights. Place the vice on a surface plate or the machine table, measure with a dial test indicator as is



shown in **photograph 18**. Determine how much the sliding surface of the vice body adjacent to the jaw is lower than at the leadscrew bracket end.

To correct this error, it will be necessary to machine the top of the two small pads on the base as is shown in **photograph 19**. As the distance from the pivot to these pads is greater than that between the two points measured, the amount to be removed will be greater than the measured value.

Set up the vice on the machine table with the vice raised into the upright position to permit machining of the pads.



Calculate from the measured value the amount to be removed and machine over the two pads removing the amount decided. Do be careful and remove less rather than more – it is easier to return to take a little more off, than to have to build these faces up again.

Having made the first cut, lower the vice and measure as before. If it is still required to remove more, go through the same process again repeating until the vice is parallel to its base.

The base sides

As the width of the vice main body has been reduced, it will be necessary to reduce the width of the base to ensure the side pieces fit correctly. Because little attention has been paid to machining the various parts to particular dimensions, the

amount to be removed from the sides of the base will be unknown and probably not equal.

With the vice assembled, measure, using whatever method is available, the amount to be removed from each side. Dismantle the vice and return the base to the milling machine. Position this on the table with some packing between it and the table. This will ensure that, when machining the sides, the cutter can be kept away from the table to avoid damage.

Set up the base with the rod parallel to the cross travel and machine the sides as indicated in **photograph 20**.

The jaw top surface

Now assemble the vice for the last time paying particular attention to cleanliness, and lubricate as is appropriate. Even if not there originally, a steel ball to act as a thrust bearing, placed in the hole for the leadscrew, will improve its operation.

Return the vice to the milling machine, machine the top of the vice jaws as seen in **photograph 21** (this used on the first page of the article, Ed.), this to ensure that these are parallel to the vice base.

It will be seen from the photographs that the vice has ended up without the loose jaw faces being replaced. There are points to be said for and against this; if replaced, or renewed, these will also require machining on the top and side faces in a similar manner to previous operations.

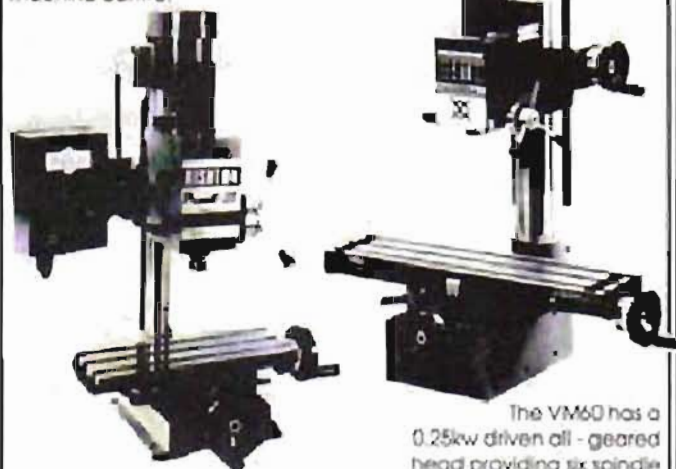


Jaw lift – a final thought

Any reader who feels that this lengthy process is not warranted should still consider carrying out the work to limit jaw lift. This will result in a considerable improvement for only limited work.

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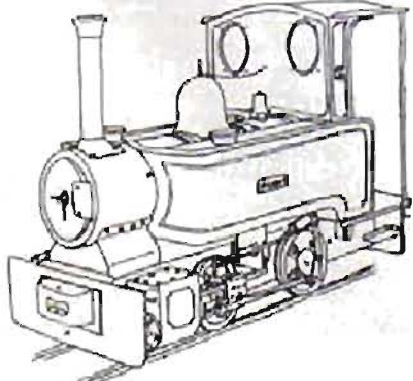
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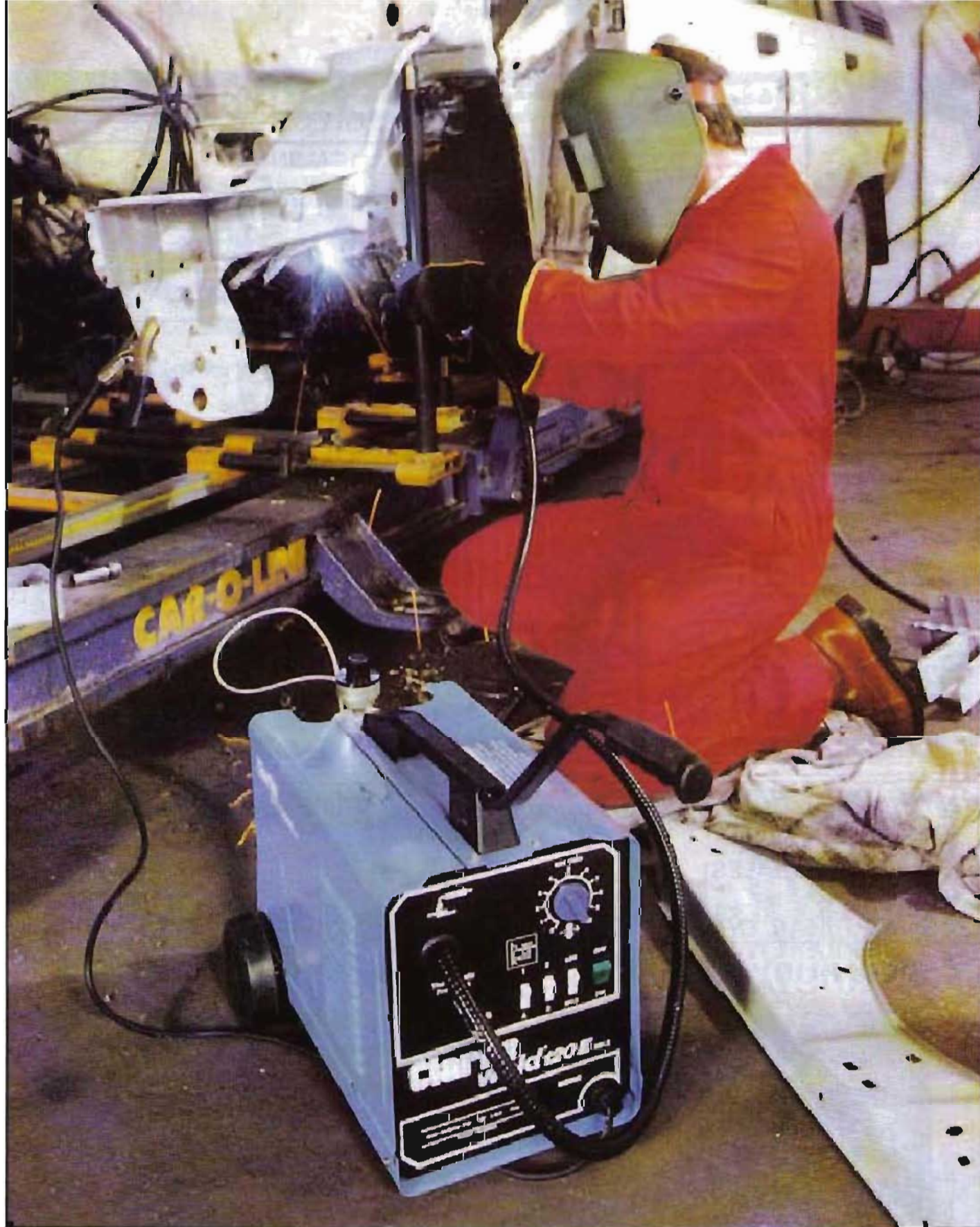
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M.I.G. WELDING

Bill McClean has had considerable experience in MIG welding having been manager of a company with 50 plus MIG welding sets. He has also taught at various technical colleges. He provides this article for us on the subject of MIG welding in the home machinist

workshop. This article refers to an earlier article on arc welding in the winter 1990/91 issue of *MEW*, and being one of the earlier issues many reader will not have a copy. Because of this an abbreviated reprint follows this.

Opposite: A Clarke MIG welder, seen here in use on a car body repair. Note that the operator has first cleared the area of inflammables and is wearing sensible clothing to cover his body whilst undertaking the job.

As a follow up to the article in *M.E.W.* Winter 1990/1991 on electric arc welding, which has considerable relevance to M.I.G. welding; we offer this article on Metal Inert Gas welding in the home workshop. Of the two processes, M.I.G. is easier to master and is more versatile when working on light gauge metal, and welding aluminium.

Specification

Metal Inert Gas (M.I.G.) welding falls within the classification of fusion welding, which covers those processes that depends on the complete melting or fusion of the surfaces to be joined. The joint is made with the addition of fused filler material, the molten contact faces being joined without the application of pressure. The term 'Inert' is somewhat of a misnomer when used in this context; the primary shielding gas used is Argon or one of the Argon based mixes; but CO_2 is widely used as a shielding gas when welding mild steel, which gas has a slightly oxidising effect on the molten pool.

When molten metal is exposed to the air, complex oxides and nitrides are formed which result in impurities in the weld, giving a poor, unreliable joint. Hence it is essential to shield the molten pool from the atmospheric gasses to prevent contamination.

Equipment

M.I.G. welding sets are now widely available at prices ranging from £120 upwards; the smaller sets work off a standard 13 amp socket, current drawn is from 6 to 11 amps according to size; as such they are well suited to the home workshop. At least one national D.I.Y. outlet stocks these, also see adverts in *M.E.W.* and *M.E.* by Machine Mart, Weldmet, Youngs of Twickenham, etc. Most of the smaller sets use 0.6mm dia. wire; and miniature gas cylinders which are not refillable; but what an addition to the spares box! Some of the sets advertised mention "no gas needed"; or "gasless" M.I.G., these use special weld wire with a flux core to provide shielding. A conversion kit to allow gas to be used with standard weld wire is available as an extra. Both types of set have their attractions, "you pays your money and takes your choice". I suspect welding costs are about the same with either, but confess my personal view is that a straight (gas added) set is more versatile, especially if welding aluminium is envisaged.

When welding stainless steel or aluminium it is essential to use Argon as the shielding gas and filler wire appropriate to the parent metal. For mild steel, and stainless where corrosion resistance is not of primary importance, CO_2 as a shielding gas gives a satisfactory weld, at a considerable cost saving.



Typical of the equipment available at reasonable cost for the amateur is this Clarke Weld 120E from Machine Mart. Other manufacturers and suppliers have similar machines available.

Safety

Protection of the eyes and skin from exposure to the naked arc is of paramount importance. Always use an approved filter glass mounted in a proper face or head screen to view the arc, filter lenses approved to B.S.I. specifications are made in several grades of density. For M.I.G. welding the appropriate grade is E.W.9 for tacking or intermittent work; and E.W.11 for continuous use. Keep your shirt collar buttoned up, your arms covered and wear leather or pigskin gloves when welding. Do not carry matches or plastic cased lighters in your pockets, and don't wear nylon clothing or socks. Weld on firebricks or a metal surface and do take precautions against fire. Make sure the floor and surroundings are dry. Keep your butane or propane cylinders well away, right outside if possible. In other words, be sensible; remember, accidents don't just happen, they are caused! Remove all oils, petroleum products and combustibles.

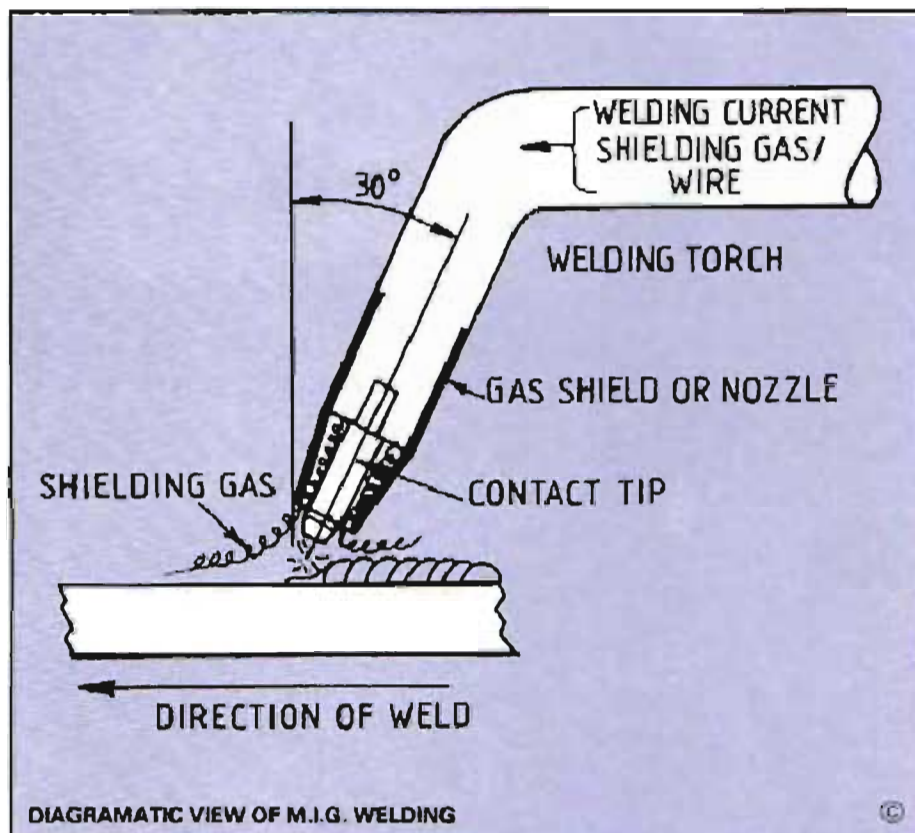
Good ventilation is essential when welding, open the doors and windows if doing a lot of welds, especially if welding galvanised metal or painted work; the fumes of these can make you quite ill; wear a fume mask, if in doubt, a 'Martindale' or similar.

Welding principles

So to some welding: Set up on a safe bench, take a quick look round to assure safety; cut a few pieces of 10 or 12 gauge mild steel sheet at 4in. x 2in., keep pliers and a set of wire snips handy.

Assuming all is connected up, switch the set on, turn the gas on and set to 5PSI approx; be careful where the wire is pointing and squeeze the trigger for about 3 seconds; the wire should issue from the nozzle and you should hear the hiss of gas; if not check your set's manual instructions on getting started. Then repeat this test. When you have obtained the desired result, clip off the surplus wire to within 10 to 15mm from the tip, the end of the wire should be trimmed every time before welding. Put the discarded piece of wire into the scrap bin for safety and good housekeeping! Place the torch aside ensuring the trigger is free to prevent accidental operation.

Clip the earth connector to a piece of 10 SWG steel previously prepared and lay flat on bench. Position the torch vertically above the centre of the plate with a 3 to 5mm gap from the end of the wire, some people like to have a wire "stick-out" of 20mm; and lightly rest the end of the wire in contact with the work; this can give



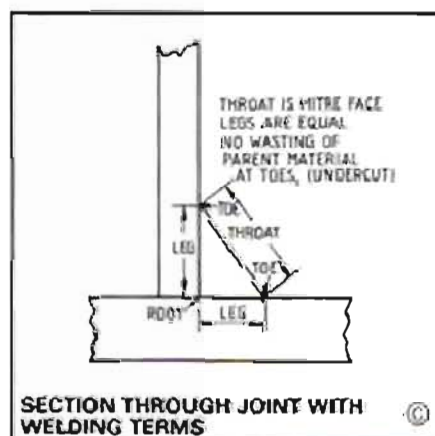
difficulty if your settings are incorrect, provided you are sure of your settings, it is in fact easier when the metal is clean to rest the wire end; hold your facescreen in your left hand, without moving the torch bring the facescreen across your face, relax!, squeeze the trigger for 3 secs. The arc should ignite or

1) The arc may spark then weld the end of the wire to the contact tip, in this case **Stop Pressing the Trigger!**, and using a very smooth file, file square across the end of the tip, which should release the wire, feed more wire through, check wire feed tension and increase wire feed control; then retry
2) The end of the wire may stick to the work, **Stop Pressing the Trigger!**, clip the wire free, increase weld setting then retry. When you are successful inspect the spot of weld metal. It should be a nice

rounded dome about 6mm in dia., and bright steel colour. Practise this, adjusting the settings slightly until you get a steady buzz with a good stable arc; the gas may need slight adjustment also. Do not try to 'feed in' the torch when welding as in stick electrode welding; this is the major benefit of the M.I.G. process; the wire is fed automatically, making the arc self adjusting to a degree. See attached charts for recommended settings, these are for guidance only as individual sets vary widely.

Reinforcing

When you are confident that you can maintain an arc and your settings are near enough correct; take a fresh piece of steel, and using a piece of blackboard chalk draw a guideline along the steel approx 1/8in. in from the edge.



Connect up the earth terminal as before, position the torch at the start of the line on your right hand side, arc gap as before, this time tilt the torch clockwise about 30 deg.,

keeping it vertical across the plate; position the facescreen and squeeze the trigger. Using the chalked line as a guide, move the torch at a steady, gentle rate along the plate maintaining a constant height, until you reach the end, stop, put your gear aside and examine the weld bead.

The line of the weld should be straight, and of parallel width, the height should be constant, the colour bright steel at the end of the weld gradually darkening to pale bluish where the heat has concentrated. The surrounding plate should be quite free from spatter, (small globules of metal adhering), there may be a few traces of scale along the edges of the weld, this is normal.

Practise these bead welds until you are proficient, you can weld alongside the previous weld and when the top surface is covered simply reverse the plate and carry on!

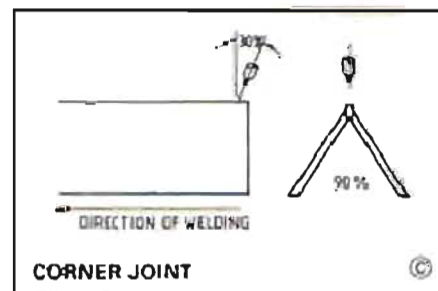
Next take a fresh plate, this time make the weld on the side farthest from you, your next bead should lie alongside and slightly overlapping the previous weld, continue until the surface is covered with weld metal; in fact this is a widely used technique to increase the thickness of metal for subsequent machining. Of course you'll notice the metal is distorted and bent! More on this later.

Turn the plate over and carry on, refining your technique and correcting your errors as you go. By now you will realise welding is HOT! Hence the pliers mentioned, don't ruin your gloves by handling hot work, it's dangerous as well, (accidents don't just happen!!!).

Keep samples of your work for comparison, looking at them encourages you to keep at it! Practice, Practise, Practise!

A corner joint

Having mastered the basics, we will now move on to learn to make joints. Take two pieces of metal, assemble them using a spare piece of angle or square section so the 4in. sides are touching with the metal thickness making a neat vee, clamp or support the metal to restrain movement,



and tack weld at the ends. Set this up as per sketch, using the same gun angles as the previous exercise weld the joint. Again examine your effort, the vee should be filled with a slight fullness of metal, again a good uniform contour and no spillage of metal down the sides. The extreme top edges of the metal should be fused and the joint if cleaned up and flattened should be of uniform thickness. This is the ultimate to aim at. Practise a few more pieces, you only need one piece of material to make another joint as there are two spare 4in. sides on your first assembly. Test one or two joints to destruction by bashing them flat with a big hammer, look particularly at

QUICK TIP

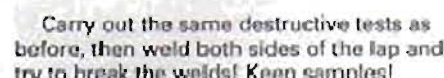
A useful source for steel balls is old discarded bearings, nor are they too difficult to remove.

The easiest method I have found is to grind a vee at least halfway through the outer casing, grind another 180 degrees from that one (opposite). Then, using a vice, lay the bearing on its side in the vice jaws, with suitable packing underneath, wrap the bearing in a piece of rag (wearing eye protection) and tighten the vice until a crack is heard. Remove from vice. The outer casing should broke in two; if not, grind through the remaining casing.

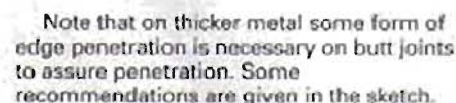
Mr Langham

Assume for the moment you are producing reasonable welds, but are 'blowing through'; perhaps at the end; try altering the torch angle slightly as you progress, decrease or steepen the angle for more heat, increase or flatten the angle for less heat. If you are really confident, try gradually lengthening the arc gap as you weld; this controls the heat input more readily. Don't overdo this or you will lose your gas shielding effect, gently and gradually is the secret!

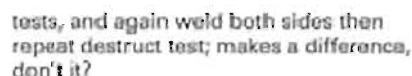
Move on to lap joints as in the sketch, which also recommends torch angles, we advise you retain right to left direction until you are proficient; during left to right welding the torch obscures your view of the molten pool, this is what you need to watch: not the arc!



The next joint to try is the downhand butt weld, again see sketches observing torch angles. The optimum butt weld is one showing a fine bead of penetration on the reverse side, and if the surplus weld metal is ground off, and the surfaces polished, no trace of the joint should be seen. It may take 100 miles of welding, but try it.

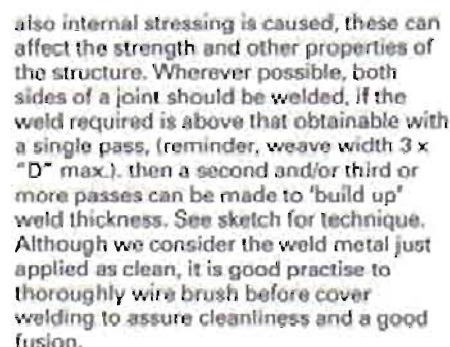


Now try the downhand and fillet joint, with the butt joint these two are the most common positions. Again do destruction



Regarding weaving, that is moving the torch from side to side to give a wider weld, the optimum width of weave is recommended as 3 times 'D'; in our case 'D' is 0.6mm, thus the maximum weave is 1.8mm. To obtain heavier welds the multi-layer technique is the correct method to use.

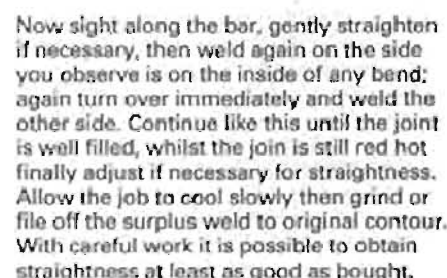
Answer "as much as it needs!". Strictly speaking, a leg length equal to 'T', which is the thickness of the parent material, provided the weld is of a good standard, gives strength approaching that of the parent material. But, because of the heating/cooling cycle, metallurgical changes take place which affect grain size.



In fact multi layer welding correctly performed improves the mechanical properties of the joint due to the normalising effect on base runs of weld of the succeeding passes.

M.I.G. welding is very successful when used as a spot welder, provided the small spot on one face is no objection; in which case it can be ground off flush. Set up as for the first exercise, (spotting on the plate). Prepare the two pieces of metal to be spot welded by wire brushing the joint faces. Decide the spacing of the spots, and drill or

Another technique especially useful to modellers, is joining two pieces of round section to make one longer piece. Grind or saw the joint faces to a chisel section, (of almost the same angle as for drills), lay the metal into a piece of angle iron and gap the joint approx. 1mm; weld across and quickly turn over and weld the second side. Do not aim to fill the joint on these initial welds.

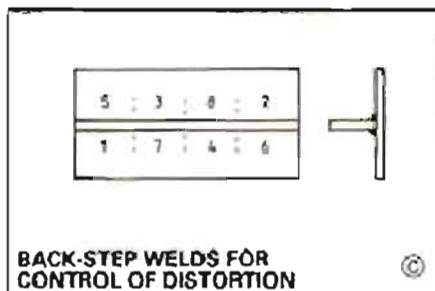


Positional welding, where the joint is in the vertical or overhead position, is a highly skilled technique requiring a high degree of competence. For the amateur, it is recommended that, if possible, work should be rotated to present the weld in the downhand position. Where positional welding is attempted, only the vertical position should be considered, using the vertically downwards technique. Butt, Fillet and Corner joints can be practised. Since gravity is now acting directly on the metal it is important not to allow weld metal to run ahead of the molten pool, which metal will solidify and result in little or no penetration. Torch angles and machine settings are much more critical for positional welding, as is speed of welding. Again practise and critical analysis of results are the way to progress.

Distortion and control

By the nature of the process, welded structures will either distort, or if distortion is prevented by jiggling or clamping, internally stressed. In practice, it is virtually impossible to prevent all distortion, thus it is wise to know about this and either offset the piece and allow the weld to straighten the offset, or allow additional metal to permit subsequent machining to desired form.

Application of distortion control techniques such as staggered welds and intermittent welding can be effective on a lot of structures. Knowing distortion will occur and allowing for it at the design



BACK-STEP WELDS FOR CONTROL OF DISTORTION

stage is the most effective way of minimising the feature. Good, sound engineering design practises should be observed when designing for welded joints. Abrupt changes in section should be avoided, when joining thick section plate to thin section butt jointed, the thick plate should be scarfed to give uniform thickness at the joint.

Machining

Welded structures required for subsequent machining may be stress relieved or normalised by heating to 900 deg.C and allowed to cool slowly.

When machining, use sharp tools and proceed slowly, the surface of weld metal

is hard; once the weld surface is removed, the underlying metal is more normal; before machining starts, a touch with a 60 grit grinding wheel to remove the surface works wonders.

Aluminium welds

For welding aluminium, M.I.G. is the most suitable process. Pure Argon should be used as a shielding gas, and wire appropriate to the base metal. Joint faces should be mechanically cleaned immediately before welding to abrade the highly refractory oxide present. Distortion is much more of a factor to contend with, due to the high co-efficient of expansion, and due to the high reflective surface, precautions against flash and radiation is even more vital when working with this metal. Additionally, the greater heat conductively can mean that areas you consider cool when welding steel will most certainly be too hot to touch with aluminium. When welding aluminium it is difficult to see the molten pool, as the metal does not 'glisten' as with steels, thus it is dead easy to melt through, plenty of practise is the answer, if observed closely, the metal can be seen to 'crinkle' just before it collapses into a hole.

QUICK TIP

Run a nut along a screw before shortening and filing to length. By almost removing the nut then again running it back along the screw, any deformed threads and "wire ends" are realigned ready for a final touch with a file. Then the nut may be removed without binding.

W Brian Taylor

ELECTRIC ARC WELDING

The following is an abbreviated reprint of a welding article from the Winter 1990/91 issue of MEW.

Welding is a process of joining metals by softening the edges and then fusing them together. Many years ago it was always a source of wonderment to watch the local blacksmith mending farming equipment by welding. There was none of the sophistication that we know today, both pieces were put in the furnace until they were almost white hot and then hammered together, sometimes with a form of lap joint. On other occasions the two pieces were simply hammered together. Of course, it took many heatings and required a great deal of skill, something that was rarely appreciated.

There are now many forms of welding used for different purposes, but it is proposed here to deal purely with electric arc welding. The reasons are simple. Firstly, a number of the projects in this magazine have called for welding. Whilst this does not necessarily mean arc welding, that certainly would be the quickest method. Then there is the fact that electric welders have, over the years, dropped in price to a level where a large number of home enthusiasts can now afford them. The third and most important reason is that a number of readers have written to say that they have bought small welding sets but cannot get the best from them.

It is not possible for a mere magazine

even though it is *MEW*! to pass on welding skills. A good welder earns a great deal of money because acquiring such skill is not easy and top people are not easy to find. We can offer some hints and tips on the best way to go about things but, when it comes down to it, the final result will only come with continual practice, and self criticism.

The equipment

Whilst for individual purposes there is a choice of many types of electric welders, for the average person in their home workshop the choice is narrow to two types, partly because a welder is needed that can be plugged directly into the normal thirteen amp socket. There are M.I.G. welders these days, very fine pieces of equipment. These will do a very good job, and they actually weld the metal through a film of gas, a process which has many advantages. In this article we are concerned with pure arc welding. This is sometimes called "stick welding".

For competitive price and for size of equipment the air-cooled welding set comes into its own. Most have thermal cut outs to prevent welding being carried on or for too long a period and so ruining the transformer. As a rule, the time allocated before the set cuts-out is ample for home workshop usage. Prices obviously vary from maker to maker and often also govern the power available; it is as well to get a set with as much power as practical within the limit of one's pocket.

Electrodes

Arc welders work as a result of the heat created via an electric arc. To make this arc, an electrode - more commonly known as the welding rod - is used. This is a steel rod coated with a flux. As the arc is in progress, the rod melts away and so gets continually shorter. The question of the correct electrode or rod to use is not an easy one to answer. There are very many varieties, mainly designed for different purposes and so the manufacturer's instructions must be used as a guide as to whether or not that type of electrode is suitable for the job in hand. They also come in different sizes. Most home welders will need one of the smaller diameter rods. Current rating of the transformer (all have a range of settings) will depend on the diameter of the rod used as well as the thickness of the metal to be worked on. Here again, practice is the important thing but a rough guide is to use one amp or current for every one thousandth of an inch thickness of welding rod.

Safety

Safety in welding is, like all other engineering practices, of the highest importance. There is a particular danger in this case from the arc itself. The eyes must be protected with a properly made piece of glass at all times. When the arc is in operation, both ultra-violet and infra-red rays are created and these can cause very nasty skin burns. In particular, they can affect the eyes, there being a particularly painful effect known as 'arc eyes'.

Different grades of protective glass are designed for different current ranges in use and it is better to use a heavier one than necessary. The use of a lighter type than that recommended can result in permanent eye damage. If a welding set is purchased new then, as a rule, the manufacturer supplies a hood or shield with the correct glass already fitted. The glass can be either in a hood or a face shield. The hood is

Stainless welds

Stainless steel can also be successfully welded using M.I.G. 95% Argon/5% Oxygen mix is recommended and again appropriate grade stainless wire. When joining stainless to mild steel, always use stainless wire and Argon mix gas; however, if corrosion resistance is not a priority, CO₂ gas can be used to weld either stainless to itself, or to mild steel.

Copper welds

Copper can be welded with M.I.G., again using Argon gas and copper welding wire. A preheat is normally required. Weld wire at 0.6mm dia. might be difficult to locate.

Shielding gasses

Miniature gas cylinders are generally Argon; in this format they are expensive if you intend a lot of welding. You can either try to obtain 2000cu.ft. (industrial standard) cylinders from B.O.C. etc., in which case you will also need an Argon regulator. (*The addresses of stockists may well be in Yellow Pages - Ed*). One of these cylinders will last you months, and is the most economical way to obtain shielding gas, saving the expensive Argon for jobs requiring it! Please remember that bulk

supplies of these gasses are at extremely high pressure, and appropriate precautions when using or storing must be observed.

Video

Again referring to the stick electrode article. There is a video available on M.I.G. welding from the Welding Institute, which the editor has made available in a similar manner as the stick electrode video.

Conclusion

In conclusion, welding is a very wide and diverse subject, with several institutes and research associations devoted to the 'black art'. Readers wanting more, should enrol at the evening classes at their local technical college, where they will find a class suitable to their requirements. LBSC used to say, "Don't take too much off, you can't put it back on". Get a M.I.G. set, and within limits, YOU CAN!!!!

Finally, have fun; producing a good weld is a very satisfying experience; safety is your first responsibility, and model engineers are generally aware of hazards in the workshop. Aim to use your M.I.G. equipment as you use your lathe or milling machine, with respect and awareness.



OUR COVER PICTURE

It is stressed that the photograph on the cover was specially taken for dramatic effect, in fact one could not weld successfully in the conditions which obtained here. The job was set-up, and tacked in the normal way, then, to make sparks for the effect we wanted to achieve, the shielding gas was turned off and the weld commenced. After the photo session was completed the large blob of poorly adhering weld metal was removed using the angle grinder and the weld was completed in more conventional fashion, with a lovely fillet and no sparks! The completed job is now in service, it mounts to the left end of the power hacksaw's vice and the outrigger is used to support long bars held for sawing. One of those little jobs which have cried out to be done for years, it took the need for the front cover to bring it to fruition. MIG welder used is a conventional off the shelf type, using 0.6mm wire.

better, as it gives greater protection but some welders find they can use a shield better than the hood and prefer it that way.

Never be tempted to use sun-glasses or even glasses designed for gas welding purposes for arc welding; the arc can cause permanent eye damage.

Other vulnerable parts of the body should also be protected; arms should be covered and necks also covered by a heavy overall or coat. Gloves should always be worn to protect the hands from burns. It hardly needs saying that slippers, sandals, etc., should not be worn. Remember that hot pieces of metal fly off the work when welding, and you must be protected. Welding sets should be switched off as soon as work is finished - you are dealing with heavy and dangerous electric currents, and whilst there is no danger under normal circumstances, it is silly to get careless.

The arc

The arc is created by striking the electrode on the work and quickly removing it to a suitable distance where the arcing effect will continue. This, for the beginner, is far from easy and the electrode will tend to stick. If this happens, the set must be switched off at once if a quick sideways jerk does not immediately free it. A cold electrode is always difficult to strike with, and a good tip is to clamp an additional plate of metal to the job. Make a couple of strikes on that to warm the electrode and then start on the actual work. The arc will be much easier to strike and maintain in position. Anyway, the practice strikes on the spare metal plate enable one to get the feel of things, and it is much better than trying to start straight away directly on the work.

Direction of weld

Always try to arrange the work so that it lies flat whilst being welded. For the novice

trying to work up and down is nearly impossible, and every effort should always be made to work on a horizontal plane. It is normal to weave from side to side when welding in order to get better coverage; this weaving effect must not be exaggerated and should only cover the equivalent of the rod diameter on each side of the straight seam being welded (total three times the rod diameter). If it is necessary to take a second run over the top, ensure that all deposited slag is first chipped away.

Coverage

All seam joints when possible, should be welded on both sides. Plates should never be butted directly up to each other but a small gap left to allow the pool of molten metal that is formed to run in and fill it. Any metal over 3mm thick should have a small vee along the seam to allow penetration of the welding material to take place.

In the case of angled joints, fillets should be built up along the edges of the metal. Again, a slight gap should be left between the metal to allow the weld to flow into position. Seams should be made along both edges.

When two different thickness metals are to be joined, it is an advantage to reduce the thicker one at the point of the weld to a thickness similar to the thinner material. If lap joints are made, then an undercut on one or both of the materials will allow better penetration.

Cast iron

Special electrodes are available for welding cast iron and these can be used for building up broken castings, etc. Care must be taken in the selection of electrodes as some leave a deposit that is difficult to machine. Almost inevitably, there will be some distortion when welding cast iron as there is with all welding operations.

Bronze welding

Bronze welding rods can be used for welding together dissimilar metals as well as bronze, etc. They are comparatively easy to use but might not be easily available. Stainless steel is difficult to weld without a M.I.G. welder but it may be possible to use a bronze rod on small stainless steel welds.

Conclusion

As stated at the beginning of this article, successful welding will depend almost entirely on practice.

Try as we may we cannot give any more than a brief account of the process in this short article. However, there is a video on the subject, entitled *Manual Metal Arc (Stick) Welding Mild Steel with Low Power Sets*. Made with the less experienced in mind, by the Welding Institute, it gives instruction on the best way to use the process. For readers who would like to pursue this fascinating part of the hobby, we have arranged for the video to be available through our Readers' Services Dept, at a cost of £24.99 including VAT and p&p. Send your order to Readers' Offers, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST, quoting RO/ME/41. The credit card hotline is available on 0442 66551.



It is recommended that plenty of practice is done on scrap material before attempting the more important jobs. Under no circumstances should the unskilled welder try making boilers; this is a job for the expert. Only a qualified coded welder should be entrusted with such work and, in all probability, an insurance company would not accept a boiler for insurance purposes unless it had been made by such a person. This apart, small home welders can be very useful for the home workshop and enlarge the scope of workshop activities considerably.

Following the description of making a light four jaw chuck, published in the last issue we now have a larger four jaw chuck, this time of conventional construction. This is from Bill Morris of New Zealand.

Just over a couple of years ago I sold my Boxford ME10 lathe and in the polite haggling with the buyer over the price, I agreed to throw in a 100 mm (4 in.) independent four-jaw chuck, as I had a 150 mm (6 in.) four jaw chuck as well. In any case, my new "Far Eastern" lathe ("East Asian" to us in this part of the world) came with two chucks, one of which was a hefty 200 mm four-jaw. There were no problems until I came to use my George Thomas dividing head which I had made with a spindle nose to go with my 100 mm chuck. It was at this point that I discovered that there was no room, even with the raising blocks, to take my 150 mm chuck, which in any case would overhang from the front of the dividing head to an unacceptable extent, as well as getting in the way of the milling cutter.

Over the next two years, whenever I wanted to do some dividing, I either made sure that I wanted only three or four divisions, so that I could use a level on the chuck jaws in the lathe, or resorted to extraordinarily shaky set ups, involving using a drilling chuck to hold work in the dividing head. A few weeks ago I decided that I had had enough and set about making a four-jaw chuck.

Methods of jaw adjustment

I had two chucks that I could copy and I used the same general proportions scaled down. There seem to be two ways used to move the jaws along their slots. Smaller chucks have a screw moving in a threaded radial hole in the body and a tongue extends downwards from the jaw to engage in a groove machined in the screw,

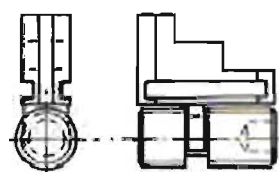
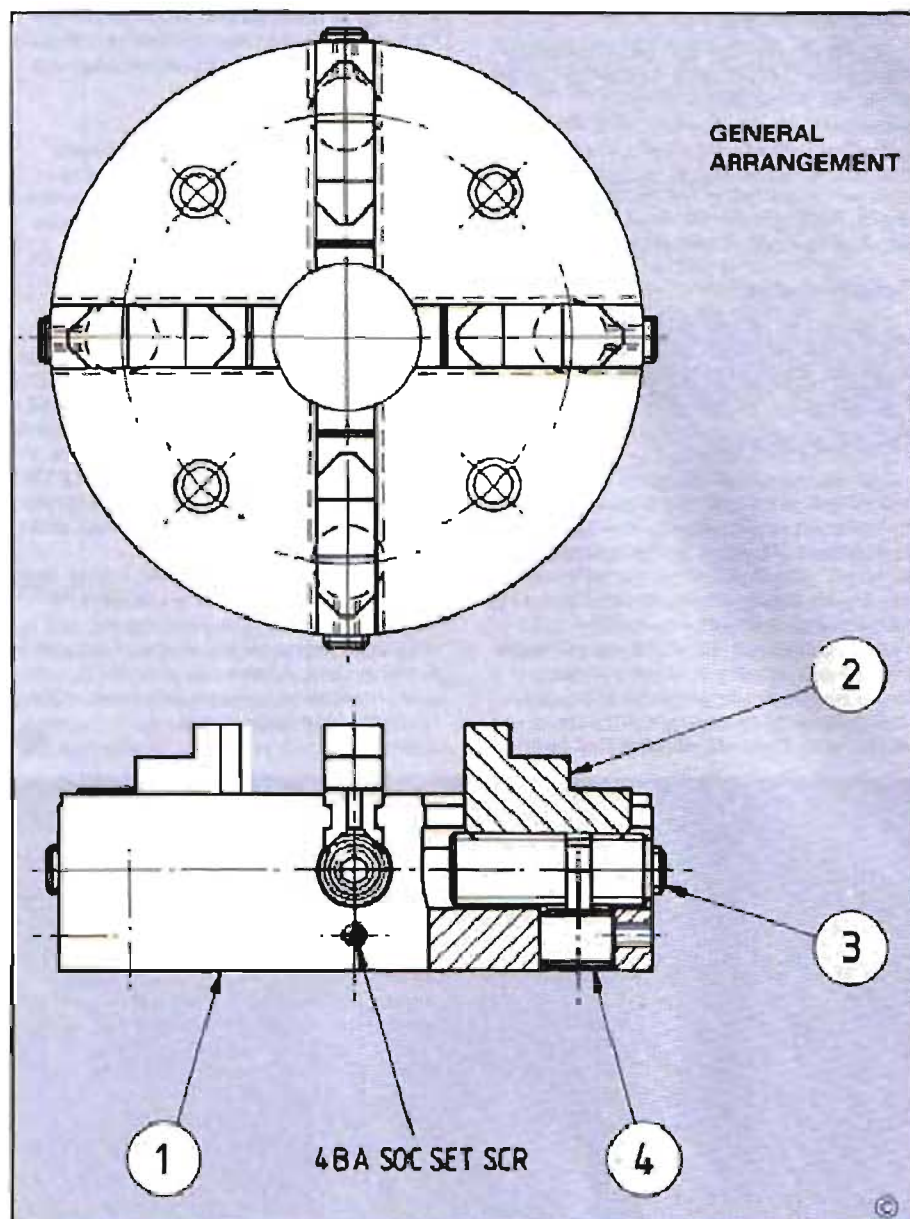


Fig. 1

so that it carries the jaw with it as it is screwed in or out (Fig. 1). Larger chucks have a screw held captive in a clearance hole by a tongue extending from a plug in the back of the chuck. The threads on the screw engage with threads cut on the underside of the chuck jaw (Fig. 2). In the first type, there are problems if the threads in the chuck body wear out, whereas in the second type the chuck jaws are usually hardened so that it is the relatively easily replaced screw that wears. It seemed to me that both systems were equally hard to produce, so I opted to copy the second system.



MAKING A FOUR JAW CHUCK

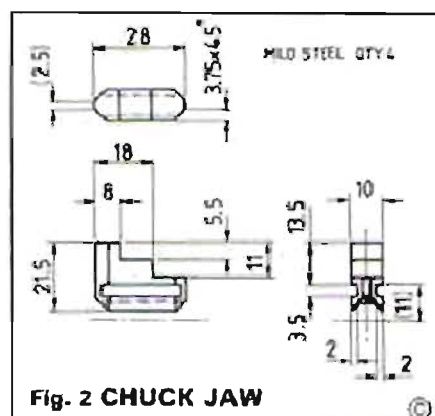


Fig. 2 CHUCK JAW

Jaws first

It is much easier to pick up a chuck jaw and try it for fit in a chuck body than vice versa, so I elected to make the jaws first. It would be easiest to make them out of cold-rolled steel, which has quite uniform dimensions over short lengths, but after visiting three local engineering works begging for scraps and being offered only hot-rolled black bar, I consoled myself with the thought that cold-rolled material does tend to become banana shaped when machining relieves the stresses introduced by the rolling. I cut myself a 100 mm length of the black stuff and milled it all over to produce a piece of smooth uniform bright steel bar. I did it in my mill-drill (East Asian,

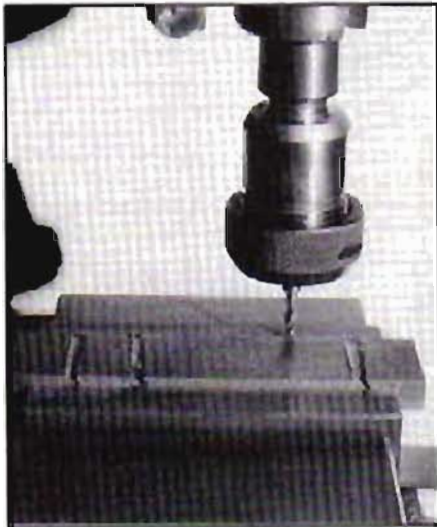


Fig. 3: Milling the slots in the jaw blank.

of course), but there is no reason why it should not be done in a lathe with a vertical slide or by holding in a chuck, a four jaw of course, and facing all over. At the same time I machined a piece of the same material about 60 mm long to roughly the same thickness and exactly the same width and cut it into two 30 mm lengths for use later.

The jaws have to be made in pairs so that the threading operation can be carried out and since it is easier to hold a long piece in a milling vice than it is to hold a short piece, I left the two pairs together for the next operation, that of milling the slots that engage in the chuck body. It is particularly important that the slot on one



Fig. 5: Drilling the jaws prior to tapping.

side should be exactly opposite its partner if they are to fit easily. I used an edge finder (see M.E.W. No. 7, pp 22-24) on the end of the bar to locate the centre line of the milling machine spindle and then kept a careful note of the longitudinal slide readings for the position of each slot. I used a 3.5 mm slot drill because I had one; no doubt a 3.5 mm or 1/8 inch slitting cutter in a horizontal machine would have made a better job of it. When all of the slots have been done on one side, remove burrs, turn the bar over in the vice and machine the slots on the other side, picking up the end of the bar with the centre finder as before

to start with. Figure 3 shows the work in progress. Incidentally, my centre finder is consistent (but how accurate? Ed.) to less than 0.01 mm using the "run out" method. I had a lapse of concentration and got the second set of slots out of phase with the first having forgotten the old adage "Cut once having measured twice." (Seems like a problem with 4 jaw chucks. See last issue 4 jaw chuck section headed "Centre bearing" - Ed.) All went well on the second attempt (Fig. 4a). It occurred to me later that I could have made a very simple jig (Fig. 4) which would have allowed me to cut one

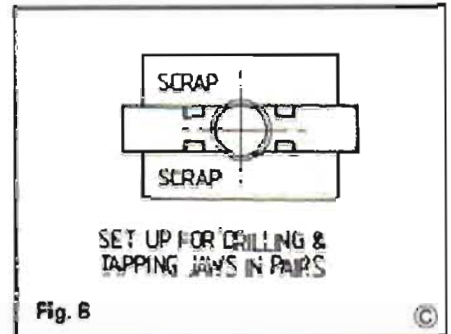


Fig. 6

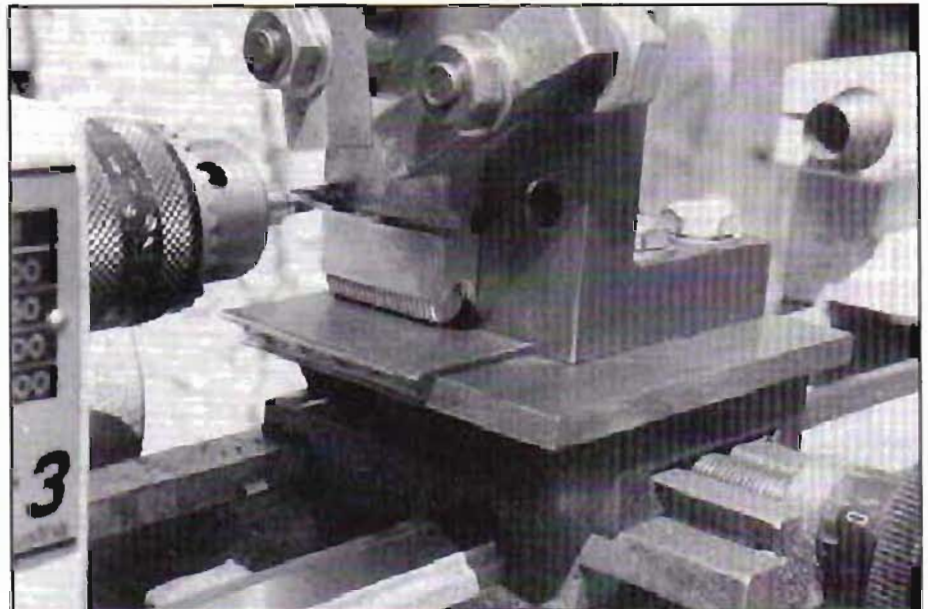


Fig. 4a: The method used by the author to slot the jaws on his chuck.

slot of a pair then to turn over the bar and cut its opposite number at the same table settings, before moving along to the next. This would make positioning independent of any lead screw or counting errors.

The next operation, having removed burrs, is to cut the threads and, since the diameter of the screws is greater than the thickness of the jaws, drilling and tapping

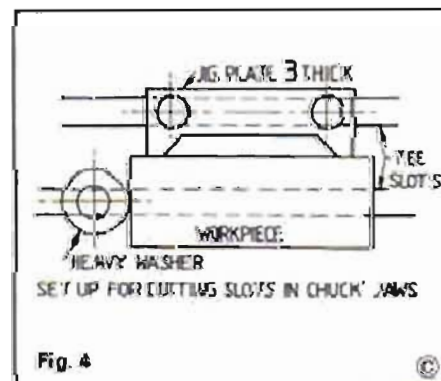


Fig. 4

takes place with the workpiece sandwiched between the two pieces of 30 mm long material previously prepared for this purpose (Figs. 5 and 6). It is important to drill and tap midway between the two embryo jaws so that the length of each jaw's "foot" is the same to avoid its screws jamming. I again picked up the datum on the end of the bar and used the lead screw to position it for drilling and tapping. When tapping is complete, the two jaws fall apart when you remove them from the vice. The



Fig. 7: Milling the bevels on a jaw.

same operation is repeated for the other pair of jaws, leaving the centre pair like Siamese twins. A little surgery with a hacksaw soon separates them.

Fig. 7 shows a rather shabby set up for milling the bevel on the front edge of a chuck jaw. A scrap piece of 12 mm screw protects the thread in the jaw from the vice jaw, but I should have done this operation at an earlier stage, before machining the steps in the jaw, so as to give a greater gripping area for the vice. File a fine chamfer on the edges of the jaws slots to make later fitting easier; and remove all burrs and sharp edges elsewhere.

The chuck body

Next we move on to the chuck body, which ends up so full of holes and slots that it looks like a piece of Gruyere cheese. If you can get your friendly local foundry to cut you a slice of centrifugally cast iron, this is the ideal material with which to work as it is of uniform consistency with a total absence of hard spots, so that it is a joy to machine. Take a finishing cut all over and then carefully mark out the centre lines of the slots for the jaws, continuing the lines along the sides of the body and around the back to mark the centre lines of the various screws and plugs. It doesn't much matter if the two pairs of jaws do not travel exactly at right angles to each other or if their centre lines are not exactly on diameters, but if you do the marking out using surface plate, square and surface gauge, it is not

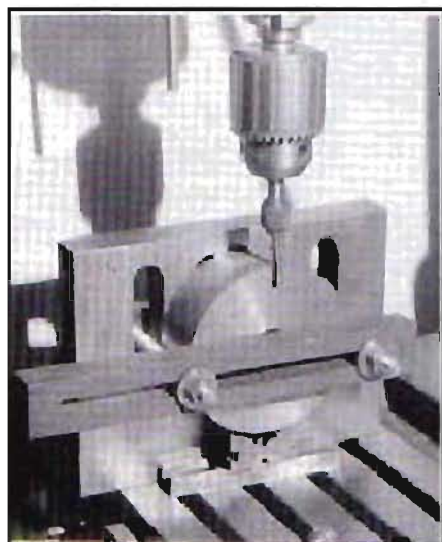
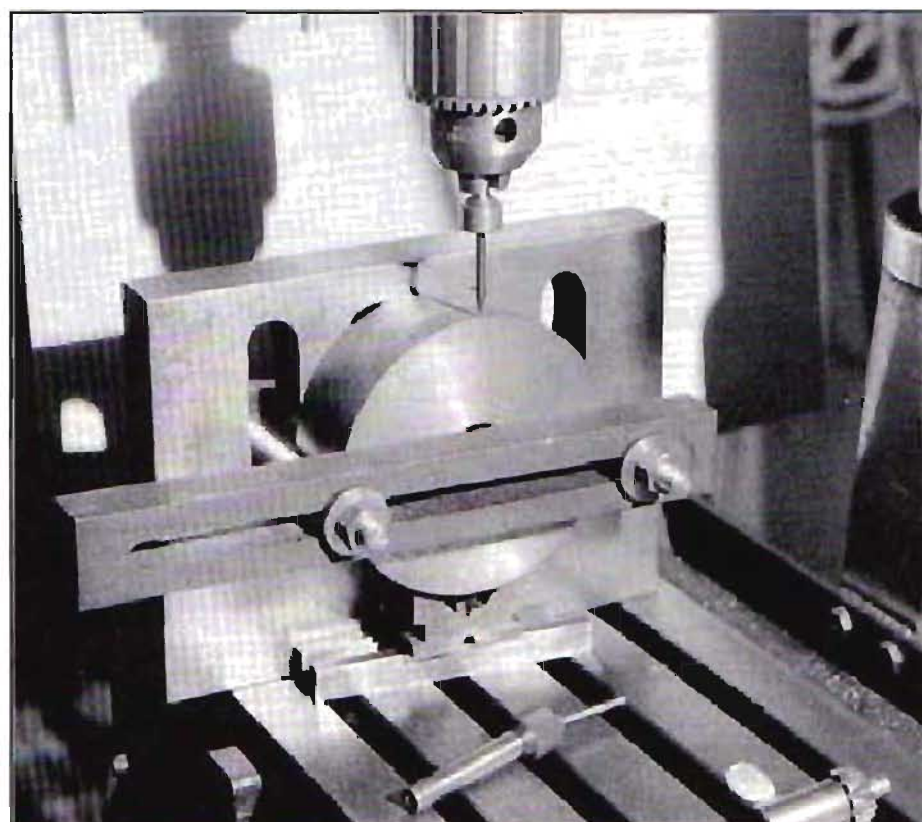
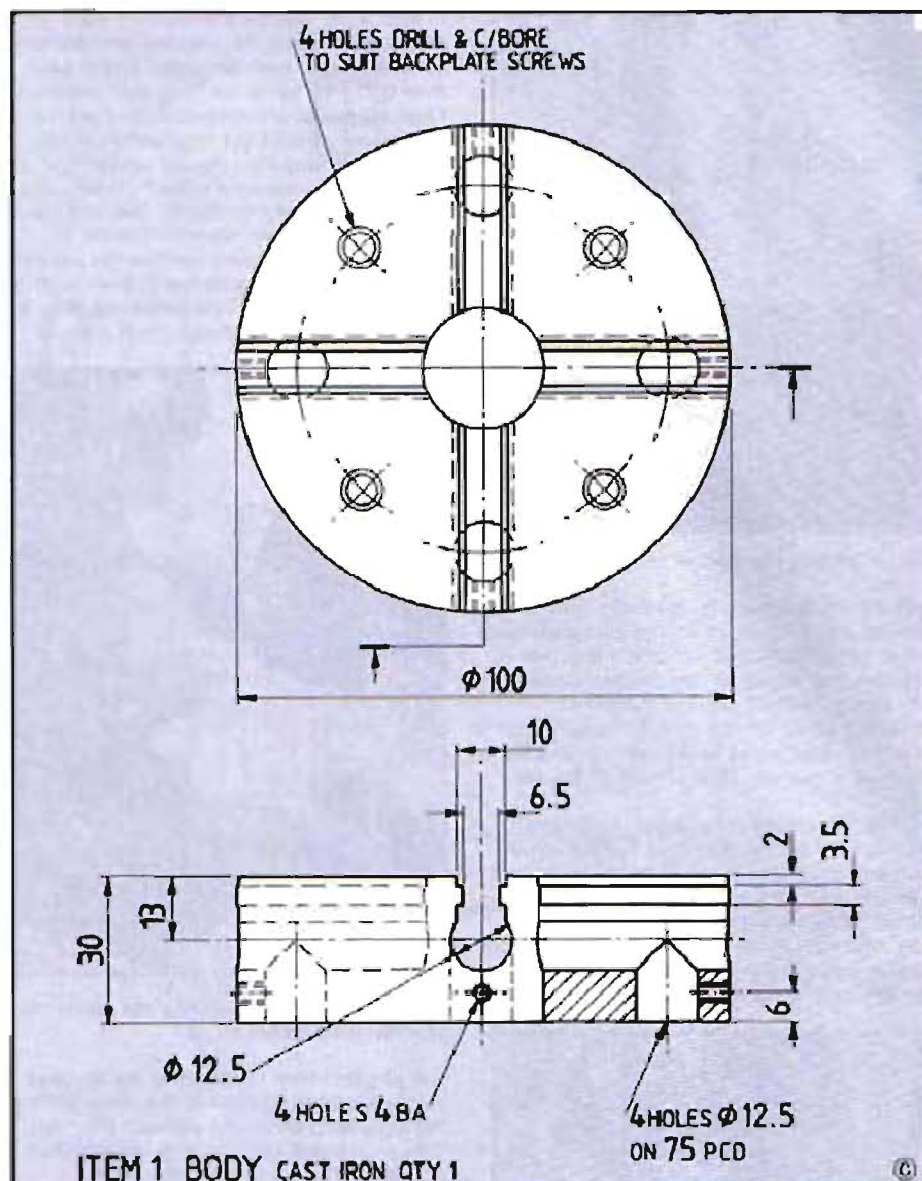


Fig. 8, above: Using the edge finder to pick up the face of the chuck body.

Fig. 9, below: Using the centre finder to pick up on the centre line.



particularly difficult to get the marking out correct. Indeed, I cannot think of any other reliable way to do it. Having marked out all the centre lines, return the work to the lathe and drill and bore the central hole to whatever size you like. If you make it too big, you won't be able to grip small work and if you make it too small it will limit the size of work you can grip securely with the whole length of the jaws, I compromised at 25 mm.

Most of the rest of the body can be machined with drilling machine and lathe with vertical slide, but it is a good deal easier with a vertical milling machine. Fig. 8 shows the body clamped to an angle plate with the centre line of the first pair of jaw slots set vertical by using a square positioned from the table as a datum. The centre line of the spindle is being lined up with the face using an edge finder and the longitudinal movement of the table. When this has been achieved the dial is set to zero and a centre finder is used with the cross slide movement to pick up the centre line (Fig. 9). I used to use a x 10 hand lens to pick up lines in this way, but found that its working distance of less than 10 mm was rather too short for comfort, I would frequently get in my own light and my face brushed against oily things it ought not to. Recently I made myself a x 8 telescope with

a working distance of 100 mm from my box of optical scraps. My wife no longer complains about the oil in my beard and I no longer curse that I cannot see what I am doing. Having picked up the face and the line it is then a simple matter to wind the table along to the place where you want the clearance hole for the jaw screws and follow a large centre drill with a 12.5 mm drill (Fig. 10). If you do this on a mill/drill,

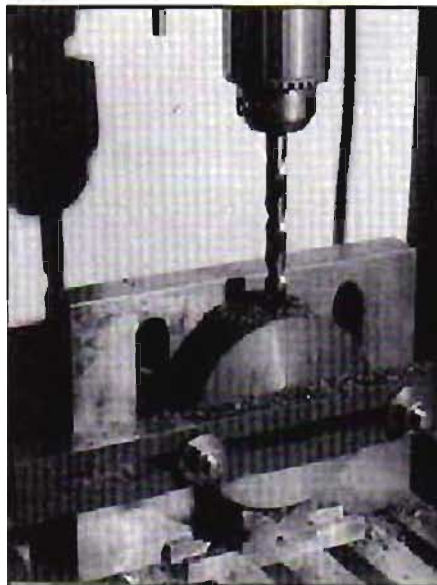


Fig. 10: Drilling the screw holes in the body.

it will save bad temper if you check first that you can substitute all the bits and pieces – edge finder, centre finder, centre drill and clearance drill – without having to move the head up and down the column and thereby losing alignment. If you do the setting up carefully, you should find that the drill will pass easily through the hole from one side of the chuck to the other.

A diversion – a T slot cutter

It is necessary at this point to digress and make a T-slot cutter. I suppose the slots in the chuck body ought to be called H-slots, at least, this is what I will call them from now on. When fitting the jaws to the slots, there are several potentially interfering surfaces and it is difficult when a jaw won't enter its slot to locate the problem. The most important thing is that a jaw does not rock along its length, so the cross-bar of the H must fit snugly in the slot in the jaw. After experimenting with a simple T-slot cutter and losing settings when transferring from above to below the cross-bar, I decided that a special H-slot cutter would simplify matters and it turned out to be no more difficult to make than a T-slot one. The cutter is made from silver steel turned down to a diameter about 0.1 mm less than the thickness of the jaws. A groove slightly wider than the thickness of the cross bar and deep enough to accommodate it is cut with a parting tool and undercut on both sides with left and right hand facing tools to provide clearance. There are many ways of cutting the teeth. I planed them and since the workpiece was held in a four jaw chuck, I used a level on the chuck jaws to give me four teeth (Fig. 11). There is nothing very special about the rake of the teeth. If the planing tool is set on the centre line, the teeth will have zero rake which will do for

cast iron, though a few degrees of positive rake cuts more freely, so I set the tool just above the centre line. The clearance behind the cutting edge can be done carefully with a file. Again, it does not much matter how much clearance; some clearance is enough. Hardening by heating to a bright red and quenching in water is routine. However, the method we often use for tempering single point tools, of heating the shank and watching the colours creep up to the point before quenching at medium straw won't do here. No doubt there are many methods, but I used the one I learned from reading Nevil Shute's excellent novel *Trustee from the Toolroom*. You immerse the hardened tool in a small tin of sand just below the surface in company with a clean, oil-free 8 mm ball bearing which you leave with about a third of its surface poking out above the surface. Then heat the sand slowly from below and when the bearing takes on the correct tempering colour turn off the heat and let the sand cool down. I finished off by touching up the teeth on my Quorn cutter grinder.



Fig. 11: Planing the teeth on the H slot cutter.

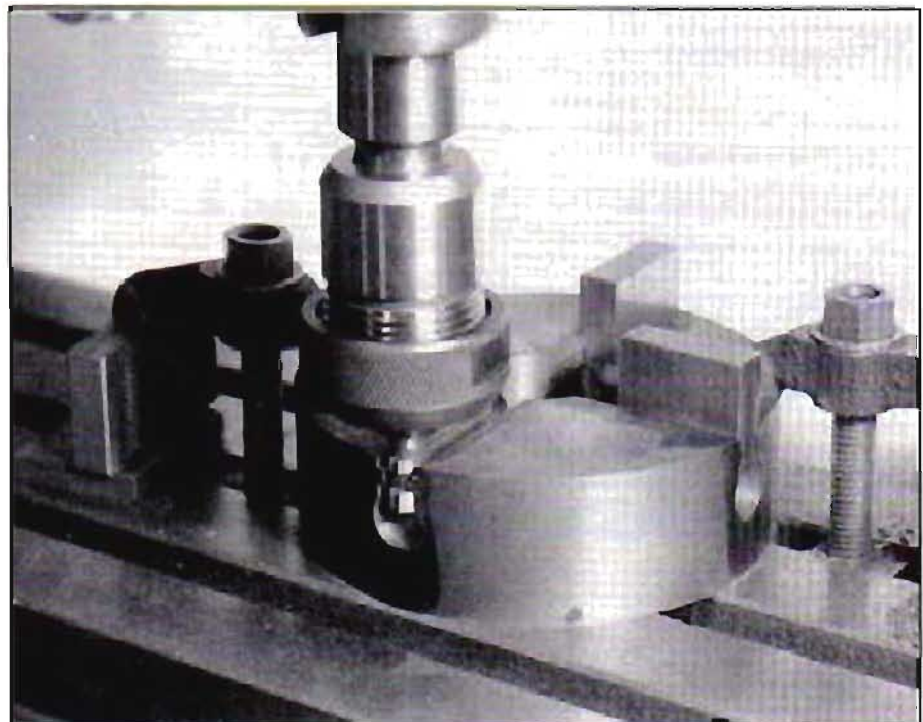
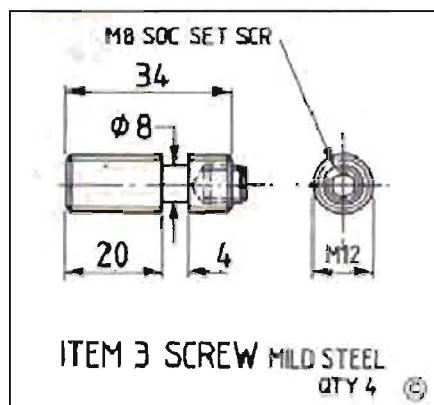


Fig. 12: The H slot cutter completing its cut.

Finishing the body

To return now to the chuck body, this is set up on the milling table, aligning the centre lines with the table using centre finder and magnifying glass. Lock the cross slide and then, taking two or three passes with a 6.5 mm slot drill (or end mill, since the width is not critical), open out the central slot into the screw hole. Replace the slot drill with the H-slot cutter and lower it until it just kisses the top surface of the workpiece. Then wind it down 5.5 mm plus the thickness of the lower cutter and set the down-feed dial to zero. This will establish that the lower surface of the cross-bar is the correct centre distance from the screw centre line. Take the cut running at about 300 r.p.m. Go gently, but keep the tool cutting rather than rubbing, and all will be well. Try the jaw in the top of the slot. It shouldn't fit, so measure the width of the slot and see how much needs to come off. It should be less than 0.1mm, so advance

the cross slide the required distance, noting its dial reading, take a cut and try the jaw again, until it fits so that it will slide sweetly. Since the width of the slot is now identical above and below the cross-bar and the jaw sides are flat and parallel, the only thing now preventing the jaw fitting in its rightful place is that the cross bar is a little too fat, so apply down feed until the jaw will slide in, albeit with some resistance. It is true that there will be a little step on one side of the slots, but the chamfer that you put on the edges of the slots in the jaws will accommodate this. In principle, the jaws should be interchangeable, but I found that there were minute and inexplicable differences in fit, so now is the time to number stamp the jaw and its corresponding slot. The other pair of slots is dealt with in the same way, locking the longitudinal slide and feeding with the cross slide. Fig. 12 shows this process being completed.



The feed screw arrangement

Making the screws is simple turning and screwcutting, or you can save a little time and use ready threaded 12 mm rod. Some amateurs are capable of putting blind ending square holes in the ends of screws. I am not, so I turned down some 8 mm Allen grub screws and Loctited them into place. The fork-ended plugs that hold the screws captive in the chuck body are again simple turning and cross drilling jobs. I made mine in pairs out of some rod I found in the junk box and filed the grooves shown in Fig. 13 because I was too lazy to spend time setting them up for milling.



Fig. 13: A pair of fork ended plugs.

They are then separated and fitted to the screws. Drilling the body for these plugs is simply a matter of careful marking out and drilling. They should be a press fit in the holes, but mine ended up an easy push fit so I added grub screws for good luck. The jaws, screws and plugs can now be assembled for a trial fit and the position of the plugs adjusted so the screws turn

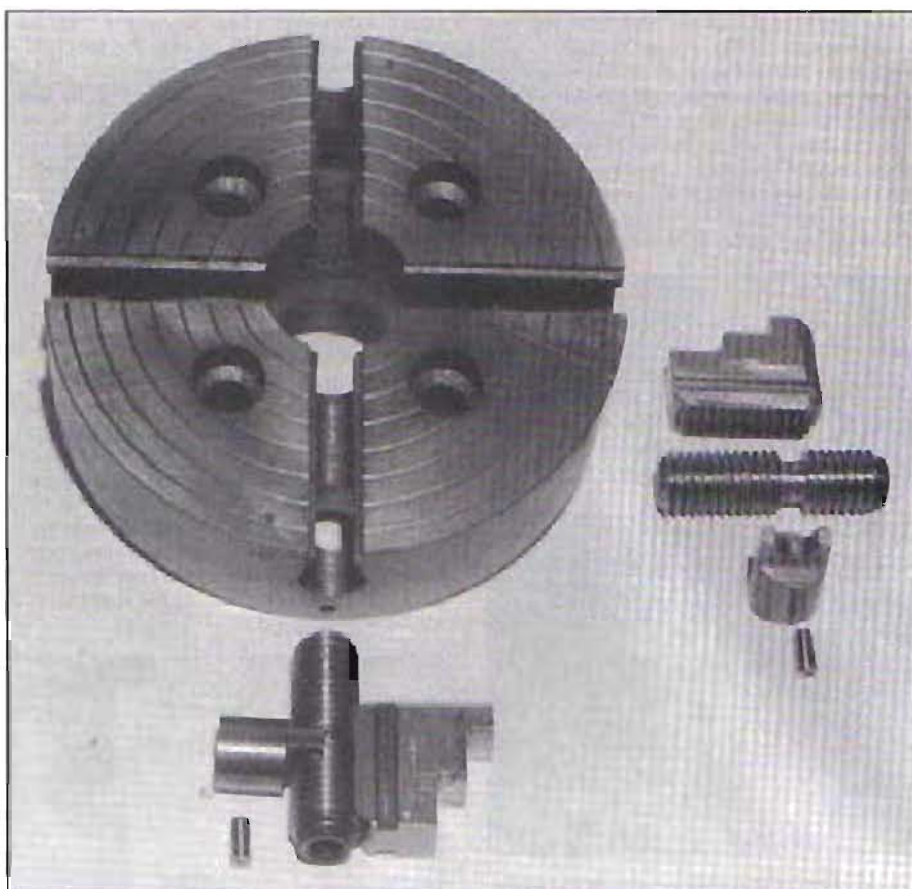
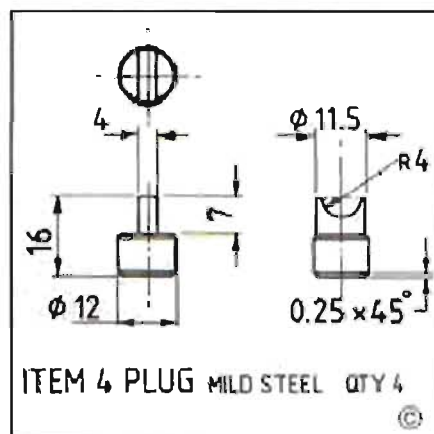


Fig. 14: An exploded view of the jaw assembly.

easily. They can then be marked from the back of the chuck, removed and turned down so that they sit just below the rear surface of the chuck body. Fig. 14 shows the completed jaws, screws and plugs in an exploded view.

The rest is plain sailing. Turn a register for your chosen backplate, spot through holes for the fixing screws and fit the plate. You can now attach the completed chuck body to your lathe for a finishing cut all over. Put in the series of concentric grooves on the face and replace the jaws for turning to shape. Put a piece of 25 mm bar in the chuck and set it running truly with a D.T.I. to fix the jaws so you can turn the steps in the jaws. As my chuck will get only occasional use, I have not case

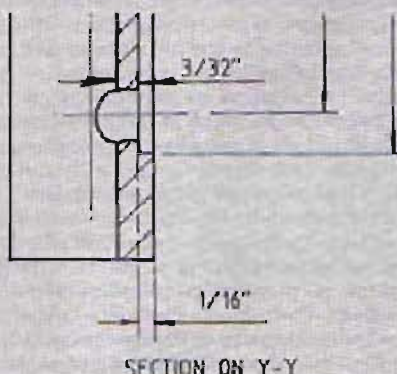
hardened the jaws, but there is no reason why this cannot be done. The final result (Fig. 15) is very pleasing and cost me about NZ\$15 or about £5 sterling for materials.



Fig. 15: The final result, a useful addition to the workshop, made at minimal cost.

An amendment to the centre-fold drawing in issue 11

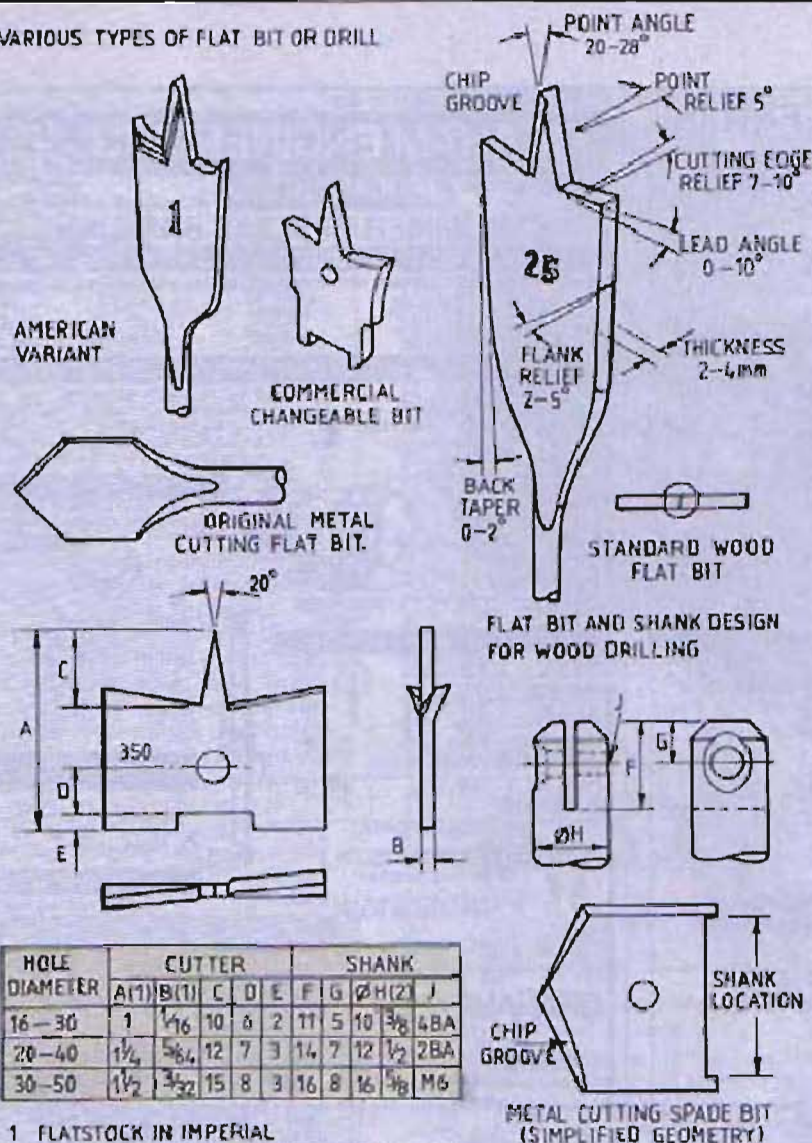
(June/July 1992)



Please amend the position of the arrow as published to that shown in the accompanying extract. These are for the 3/32 in dimension. Please amend this even if you do not intend to make the chuck, it may well save a lot of annoyance to anyone who decides to make this design at a later date - Ed.

371-373A EARLSFIELD ROAD
EARLSFIELD, LONDON
SW18 3DD
TEL: 081-874 5708-5709/9690

VARIOUS TYPES OF FLAT BIT OR DRILL



HOLE DIAMETER	CUTTER					SHANK				
	A(1)	B(1)	C	D	E	F	G	H(2)	J	
16-30	1	1/16	10	6	2	11	5	10	3/8	4BA
20-40	1 1/2	5/16	12	7	3	14	7	12	1/2	2BA
30-50	1 1/2	3/32	15	8	3	16	8	16	5/8	M6

- 1 FLATSTOCK IN IMPERIAL
- 2 SHADE DIAMETER IN METRIC & IMPERIAL
- 3 ALL OTHER DIMENSIONS IN mm

VARIOUS TYPES OF FLAT BIT OR DRILL

Peter Jones provides an article on making flat bits for wood; it includes information on hardening them which will also be useful in other applications



Milling the slot for inserts.

used in some types of flat bit and in spade drills. It is becoming increasingly common to include milled or indented grooves in the sides of the centre point of flat bits for wood to give a cleaner cutting action with less heating.

The cutting edges of standard flat bits terminate in points, known as scribes, which sever wood fibres ahead of the cut. This results in a clean bore and eases the task of the cutting edges in lifting waste from the hole. An American variant has pronounced spurs and indented chip grooves along its cutting edges and centre point which is stated to give faster cutting and longer life. Variations in geometry offered by other makers are designed to secure the widest range of applications for the flat bit. A broader centre point is said to give better stability and sloping entry although one maker states that his tools are not designed for angled entry. A zero lead angle satisfies those requiring a flat bottomed hole, while lead angles up to 10 deg. sharpen the scribes which should give a cleaner breakout in through hole work.

The flat bit depends for its stability on its centre point steering it through the workpiece and as it emerged in un-backed through-hole work there is a marked loss of stability resulting in vibration and chatter. There is also a tendency for instability to occur if the cutter is withdrawn from the workpiece while rotating and if it is re-entered into a cut. It is therefore advisable to complete the cut in one pass if the shavings are clearing and to stop the spindle before withdrawal of the cutter. This problem was not experienced with the changeable bits to be described. The flanks of flat bits do not offer sufficient guidance to prevent drills from running off-course in adverse grains.

General information

The smallest size of flat bit on general sale is 1/8 inch but most woodworkers would use woodworking twist drills up to about 1/2 inch diameter. Forged flat bits are usually offered in 1/8 inch steps up to 1 inch diameter

DRILLS FROM FLAT STOCK

Types of flat bit

The flat bit is an inexpensive and popular wood drilling tool used extensively by tradesmen and DIY enthusiasts. It is supplied mainly as a solid forged drill but is also obtainable in the form of interchangeable bits which fit into a slotted shank. Its predecessor, the forged flat metal cutting drill was replaced by the twist drill many years ago but lives on in machine shops as a spade bit. This modern version is, however, a much more carefully made tool and in one form coolant is pumped through the shank and cutting bit to the cutting edge itself. Its application is as a more economic alternative to large twist drills. On a point of terminology flat bits for both wood and metal are referred to as

spade bits in North America. In the UK the term 'flat bit' enjoys more general usage in woodworking although the metal cutting inserted bit is always referred to in machine shops as a spade drill.

How they cut

While the geometry of the original metal and current wood cutting flat bit is substantially different the cutting action is (or was) essentially that of scraping. By setting the cutting edges of either tool forward this may be changed into a genuine cutting action with the proviso that the life of the tool in this format is limited to the extent of the set. Another approach is to grind or pre-form a lip or indentation in the cutting edge and this technique is



Centralising the slotting cutter using setting spacer.

and on to a maximum size of 1 1/2 inches in 1/8 inch steps. DIY changeable bit sets are sold in a more limited range of sizes presumably because of the market demand and high cost of tooling. A set currently available is offered with inserts in sizes of 16, 20, 22 and 25mm diameter but these could easily be ground down if intermediate sizes were required. The cost saving of these changeable bits over the purchase of equivalent solid flat bits is not, however, particularly attractive. High quality flat bits are priced up to about £4.00 for the larger diameters. Lower quality bits save money but a set from the Far East purchased recently proved unusable and required re-grinding.

Standard flat bits are intended for use in power tools at high speeds and manufacturer's advice on packing usually confirms this in general terms. One manufacturer does supply a speed versus diameter chart with his flat bits, but owners of single speed power drills have no choice. Hand held, care is needed on getting holes drilled at right angles to the workpiece and, at the speeds quoted, there is considerable scatter of dust and shavings. In through drilling some splintering will usually occur on exit unless a backing of waste board is clamped to the workpiece. The alternative in the case of workpieces which can be manipulated, is to drill from both sides using the penetration of the centre point as a guide for the second cut. On site work the workpiece may be a structural member and therefore fixed, otherwise it should be clamped before drilling. A drill stand with the workpiece clamped to its table considerably improves the situation but backing waste is still necessary for through holes if a clean exit is to be obtained.

Making flat bits

Changeable flat bits can be made up from precision ground flat stock without too much difficulty and at a cost ranging from about 20p for smaller sizes to 50p for larger and thicker inserts. Made to standard geometry up to 35mm diameter they can be used in the same way as solid forged flat bits with equally good results. By setting the cutting edges forward a positive rake bit can be made which has a number of advantages over the standard flat bit with the proviso that it is suitable for use

QUICK TIP

It is sometimes difficult to set up a gear train with the correct amount of back-lash. A quick way of solving this problem is to trap a piece of paper between the gears when they are meshed. The paper will fall out when the gears are rotated, leaving a clearance.

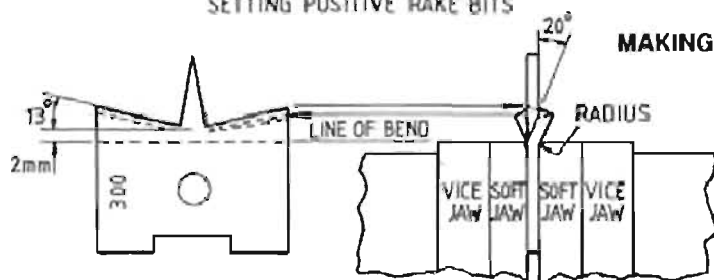
As there are many thicknesses of paper, it should be easy to find a thickness to suit any gear train, from a cigarette paper for high precision small gearing, to writing paper for the less precise and even thicker if one of the gears isn't running as true as it should

R.J. Loader

	POSITIVE RAKE FLAT BIT		STANDARD FLAT BIT
1	PAINT FLAT STOCK WITH DILUTE WHITE GLOSS. CUT OFF DIAMETER REQUIRED & SQUARE SIDES.		AS FOR POSITIVE RAKE BIT
2	MILL OR CUT LOCKING SLOT TO SHANK DIAMETER.		AS FOR POSITIVE RAKE BIT
3	SPOT DRILL LOCKING SLOT THRO SHANK. COMPLETE DRILL & CHECK SYMMETRY.		AS FOR POSITIVE RAKE BIT
4	MARK OUT & CUT CENTRE POINT & CUTTING EDGES (DEVELOPED SHAPE) CHECK SYMMETRY.		MARK OUT & CUT CENTRE POINT & CUTTING EDGES TO FINAL SHAPE. CHECK SYMMETRY.
5	CLAMP BLANK BETWEEN SOFT PLAIN JAWS. USING A SOFT RECTANGULAR PUNCH SET CUTTING EDGES.		OMIT
6	FILE CUTTING EDGE RELIEF. CHECK SYMMETRY.		FILE RELIEF ON CENTRE POINT, CUTTING EDGES & FLANKS. CHECK SYMMETRY.
7	HARDEN & TEMPER		HARDEN & TEMPER
8	GRIND CUTTING EDGE RELIEF ANGLE USING CENTRE POINT AS GUIDE.		GRIND CENTRE POINT & CUTTING EDGE RELIEF.

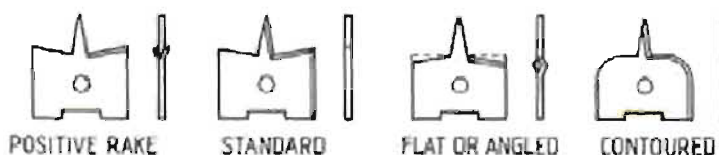
SETTING POSITIVE RAKE BITS

MAKING FLAT BITS



THROUGH OR BLIND HOLES

BOTTOMMING



DIFFERENT STYLES OF FLAT BIT

only as a machine bit on a pillar drill or lathe with the workpiece clamped. The forward setting of the cutting edges produces a scribed diameter slightly larger than the flank diameter and because of this I have found it unnecessary to provide back taper or flank relief. With the slower speeds used I have also found it unnecessary to provide relief on the centre point. With

keener scribes a clean exit without waste backing can be obtained and this is useful in lathe work where it may not be possible to back up a workpiece clamped in a chuck. Finally much less dust is produced at the slower speeds used with shavings piling up neatly around the drill.

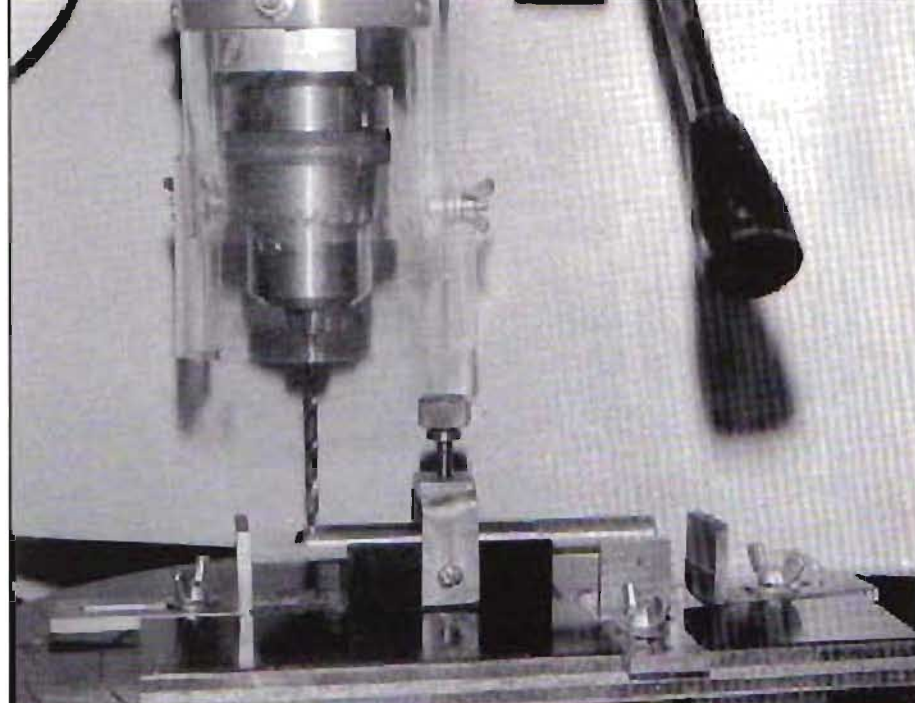
Making shanks and inserted cutter bits is an interesting project which can be

undertaken with only basic workshop equipment but makes full use of more elaborate gear if this is available. The operations involved are slotting and drilling the shank and cutting out, hardening and grinding the inserts. Flat bits for wood will tolerate some inaccuracy and will work if only one edge is cutting. New sizes can be added as and when required and inserts may be shaped to bottom holes in any concave or angular form required.

The shanks

Forged flat bits have shanks from 6.5mm to 7.5mm in diameter which are stated by manufacturers to have been heat treated. The one set of changeable bits in my tool kit had a $\frac{1}{8}$ in. diameter shank which was soft. With the above in mind I felt that a $\frac{1}{8}$ in. diameter shank made from bright mild steel should be strong enough for cutters of smaller diameter. Ideally the shanks would be made in a higher carbon steel and toughened but this would incur the possibility of loss of straightness and splaying of the slotted ends in heat treatment. The alternative would be to make them up in higher tensile steel.

If the shank is to be slotted and drilled in a vertical mill it is first clamped in a vice in a V groove and checked for alignment. The cutter position can be obtained directly using a height vernier or, if this is not possible, a spacer of the correct height may be zeroed with the top of the shank using a dial indicator. In either case it is essential to eliminate the effect of any cutter wobble by establishing a mean position from which measurements are to be taken. The depth of slot is obtained by direct measurement from the cross feed vernier. To centralise the milling spindle for drilling the shank a centre finder may be used taking readings



Spotting the position of the locking hole

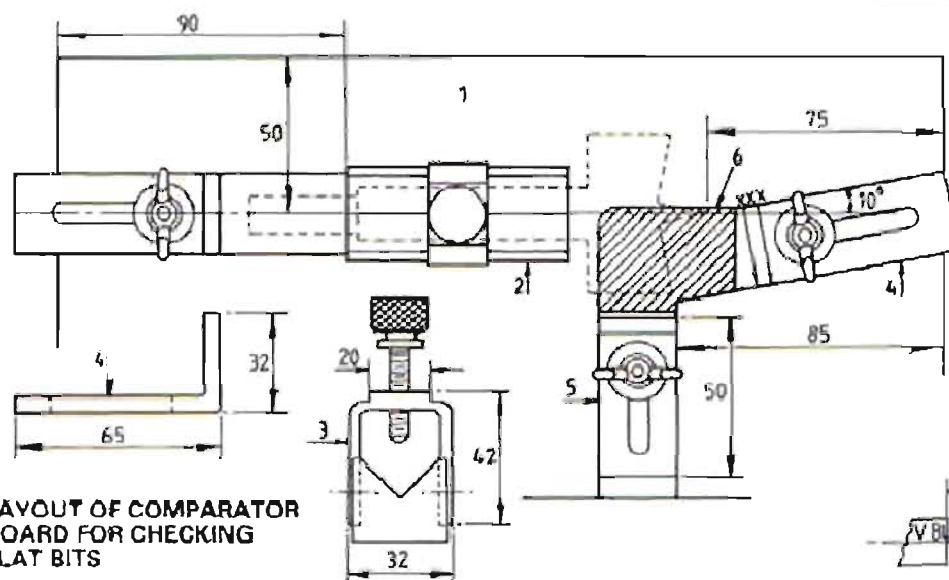
from both side of the workpiece as a double check. Alternatively a piece of stock of the shank diameter is chucked and centred over the shank using a square. Again the effect of any run-out of the stock is eliminated by establishing a neutral position using a dial indicator.

The positional accuracy of the slot may be checked using a V block and dial indicator on a surface plate with a blank insert in position in the shank. A similar check on the locking hole may be carried out by entering a tight fitting screw into the tapped hole. In both cases a tolerance of ± 0.1 mm when the shank is turned through 180 deg. will meet the requirement. I found

that cutters up to the largest size made (50mm diameter) could be driven in the Jacobs type chuck without the need to provide a hexagon on the shank. The locking screw should have a plain portion equal in length to the plain hole in the shank and the width of the slot. If a clamping effect on the insert is required this can be achieved by providing a flat on the shank in which case the screw can be round or cheese headed if preferred.

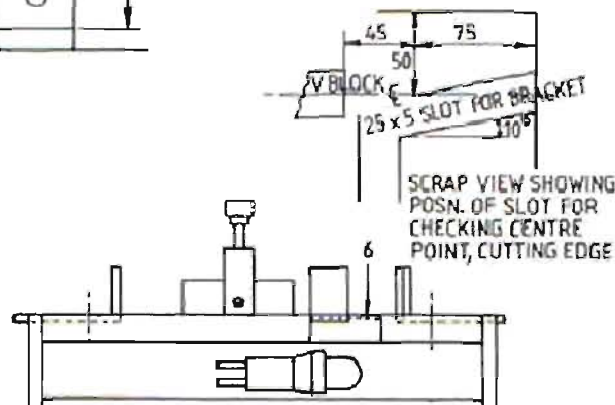
The inserts

The material used for the inserted blades was a precision ground flat stock to AISI.01



LAYOUT OF COMPARATOR BOARD FOR CHECKING FLAT BITS

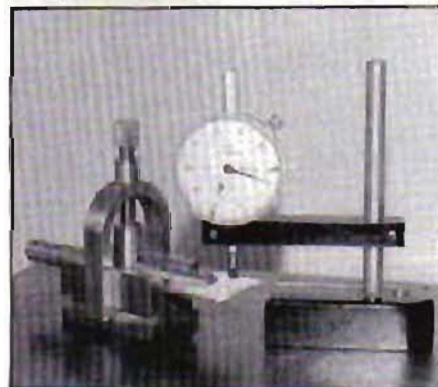
1	BASE BOARD	280 x 140 x 15 PLY FACED FORMICA BOTH SIDES
2	V BLOCK	70 x 30 x 25 TUFNOL
3	CLAMP	18 x 6ms REDUCED TO 3mm FOR BENDING
4	SLIDING BRACKET	25 x 5ms BENT UP, SPOTTED, FACED SQUARE
5	SLIDING BRACKET	25 x 5ms BENT UP, SPOTTED, FACED SQUARE
6	TRANSLUCENT PATCH	3mm WHITE TRANSLUCENT ACRYLIC



SCHEMATIC VIEW SHOWING 15W PIGGY LAMP & HOLDER

having a stated carbon content of 1%. Steels of this type have been used extensively for making form tools for turning brass and are stated to take a fine knife edge. They should, therefore, be suitable for wood machining. In its annealed condition this tool steel is easy to file and saw and I found that a worn 14 t.p.i. bandsaw made light work of shaping blades. Flat stock is sometimes offered more cheaply in surplus lists but its use for flat bits should best be avoided and purchased from a stockist selling current production material.

The cutting out procedure for both standard and positive rake bits is the same except that in the case of the latter an allowance has to be made for setting the cutting edges. I found that an angle of 13 deg. around the middle of the range of cutter diameter (30 – 35mm) covered the situation but this would need to be increased for smaller diameters and could be decreased for larger diameters. Initially the blades were 'set' on a bend line parallel to the cutting edge. Later blades were set on a line parallel to the base of the blade which saved one clamping and gave a better chance of getting the same set on both cutting edges. For this operation the blade was clamped between two soft jaws in a milling vice having a small radius on each jaw provided to avoid bending the blade over a sharp edge. A few light taps with a 2 lb. hammer and soft rectangular punch is all that is required to achieve the required set. Under no circumstances should any attempt be made to reverse the set if it has gone too far – simply leave it – otherwise the tool steel will crack. Most flat stock has a grain flow along the length of the strip so that if the length cut off forms the blade diameter the set will be in the direction of the grain. It is advisable to mark one side of the blade before too much work is done and ensure that it is always inserted into the slot the same way.



Checking that the slot is central.

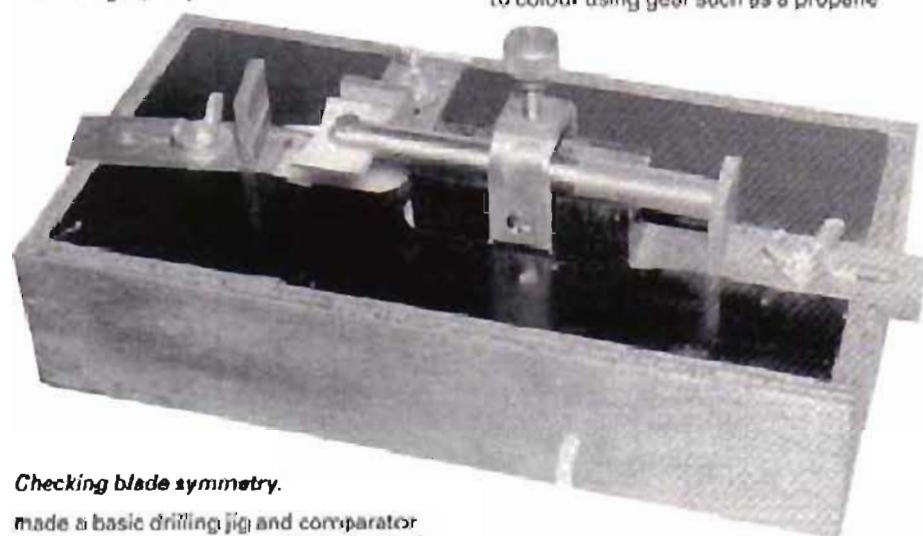
If number stamps are available it is a good idea to stamp the size on the insert to serve the same purpose.

In the case of standard flat bits all relief angles are filed on before heat treatment taking care not to encroach on the cutting edges. If this is done accurately enough only a light grind is required on the cutting edge after grinding although combining the grind on both the cutting edge and centre point may be preferred. For positive rake bits I have found it necessary only to relieve the cutting edges and again, a light grinding on the tool grinder is all that is required if preparation prior to hardening was accurate. Initially I experimented with a 20 deg. relief on the cutting edges but

this produced chatter at times and it was reduced to 10 deg. A larger clearance angle gives a sharper cutting edge for a given rake and if this is particularly required it is worth experimenting with the higher clearance as it will frequently work. The grinding wheel used for the light duty involved was 100 grit white aluminium oxide. (WA 100 KV).

Checking accuracy of inserts

If only a few bits are required a 'V' block and dial indicator can be used for symmetry checks with the blade at right angles to that used for checking slot accuracy. As a final check the cut can be stopped after the cutter has started to bite and a check made to see that both blades are cutting equally. If a number are to be



Checking blade symmetry.

made a basic drilling jig and comparator can be constructed to simplify the task of clamping up the blades for spotting through the shank with a drill and for checking other features. Using the type of fixture shown it is possible to check for symmetry of flanks, cutting edge angle and centrality of point. A light source underneath the working area is an additional aid and saves the need to use feeler gauges.

A fixture of this type may be made from any material to hand and I have indicated on the layout sketch the materials used which came out of a scrap box. Ply faced on both sides with Formica gives a good stable base board with plenty of wear life if the grooves for the sliding brackets are cut carefully. If the brackets are bent in a vice it will be necessary to mill the working faces afterwards so that they are at right angles to the base and sides of the brackets. The bracket used for checking the centre point is set at an angle of 10 deg. to correspond with the point angle used. The slot for the cutter is dimensioned to cross the centre line at a suitable point and any excess material on the edge used for gauging the centre point may then be relieved to give the contact required.

Heat treatment

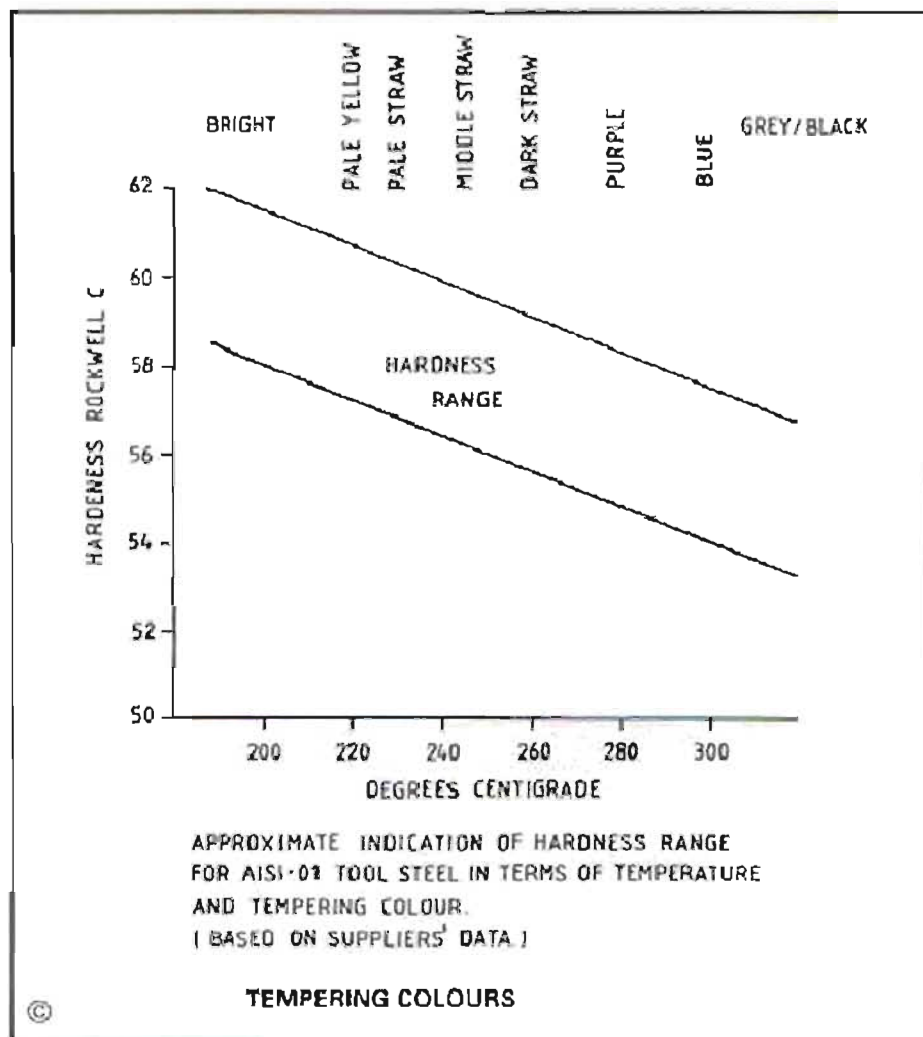
Specific values of the hardness of wood cutting tools is difficult to come by but there are a few indicators available. One European manufacturer of wood turning tools in chrome vanadium steel, for example, works to a hardness specification of 60 ± 2 Rockwell C. An American study of wood chisel hardnesses from many makers found a spread of values from 63.5 to 53

Rockwell C (corresponding to tempering colours from bright to grey). A current advertisement for cold forged flat bits states that they are hardened to be sharpened using a fine file. This would put their tempering temperature above 300 deg.C and their tempering colour into the light blue/grey area if a high carbon tool steel had been used. In a file check on my own collection of flat bits, the American variant and the changeable bit set were easily filed – the others varied in hardness and some were too hard for filing.

Makers and suppliers of flat stock provide information on the hardening and tempering of their product but this is given in terms of temperature and is designed for professional users with industrial furnace equipment. The amateur generally works to colour using gear such as a propane

torch in conjunction with a brazing hearth for hardening and a hot air paint stripper for tempering. Nevertheless, good results can be obtained on small workpieces (not involving long soaking times) by following one of the many detailed texts designed to help amateurs. As an approximate guide a tempering chart has been prepared based on information given by suppliers of flat stock to AISI-01 to which I have added tempering colours. Flat stock requires a hardening temperature of around 800 deg.C (cherry red) and is quenched in oil. Readers requiring more specific information on the heat treatment of this material are advised to contact manufacturers.

From the foregoing it will be seen that there is a fair amount of latitude in the tempering of flat bits made up as changeable sets. It is safe to assume that a maker will also be a careful user and in this he has an advantage over a manufacturer who has to allow for possible abuse. The bits are well supported in stout shanks which is a further factor justifying a higher level of hardness. For standard flat bits which are to be ground it is suggested that a dark straw would be appropriate for careful use. Although if it is preferred to re-sharpen by file this will have to be reduced to blue or possibly lower. In the case of the positive rake bits it is important for their more acute scribes to have as long a life as possible between re-grinds. I initially aimed at a middle straw for these but gradually went to a pale straw in later cutters with no breakages. I found that the bits could be tempered by conduction by applying heat



at their shank ends which offers the advantage that the body of the blade is tougher than the cutting edges and centre point. Using this method, however, it is all too easy to let the colours go too far but when this happened the cutters appeared to work just as well.

Using shop-made flat bits

The flat bits were made to support development work in the routing of internal and external threads in wood. This project involved drilling and counterboring holes of non-standard sizes in the range 14 to 50mm both on a pillar drill and lathe. All work was either clamped to the drill table or clamped in a fixture which itself was fixed to the machine table. The products were embroidery frames, traditional wood vices and clamps and details of the methods finally developed appeared in an article in *Woodworker* September 1991 pages 946 to 949. I used positive rake bits for all of the drilling work, making up new sizes as they were needed. On a pillar drill spindle speeds do not seem to be critical and a good hole can be produced over a wide range of speeds. It is, however, an advantage environmentally to be able to use lower speeds and I eventually found that the following speeds gave very acceptable results:

up to 20mm	800-1000 rev/min
20 to 35mm	600 " "
35 to 50mm	400 " "

In good class work clean entry and exit is essential. A standard wood flat bit will give a perfect entry when used as a

machine bit but fails on exit unless backing waste is used. With the positive rake bit the cutter has a tendency to raise cross grain on entry – but not seriously. It will give a good exit with care without backing but to be sure under all circumstances the use of waste backing is preferable. With standard flat bits there is a tendency for holes to be slightly oversize but with the positive rake bits I found that a large proportion of holes were dead to size as measured across the scribes of the cutter and the sides of holes were well burnished. When counterboring it is important to drill the larger hole first and work downwards in diameter. This ensures that the centre point is always in contact with the workpiece. It is an obvious advantage to be able to change the cutter without disturbing the workpiece when counterboring to ensure concentricity. I experimented with a positive rake cutter without a centre point for opening out but its performance was unpredictable and anybody wanting this would have to be prepared to experiment.

One very interesting aspect of the operation of the positive rake cutter is that it makes no difference to their performance if there is a slight blade rock on the locking screw. Indeed this may well be an advantage as it probably enables the bit to take up its best cutting position. I discovered quite accidentally that a cutter with a few degrees of swivel centred itself on touching the workpiece both when used on a pillar drill and on the lathe and went on to give a perfect cut. This would not do for a sloping entry, though, and it should

be noted that we are referring to clamped workpieces. Any long term operation of cutters in this mode would probably require a high tensile shank and locking screw and more development is required to determine whether there is any future in this approach.

The cutters were very successful in cross-grain work on a lathe but care is needed when working down grain. The drilling of 170mm lengths of 24mm diameter ramin dowel with a 15mm positive rake bit from each end produced perfect results with a perfect meeting point. (The tube was required for internally threaded inserts.) My large cutters failed to drill a coarse redwood down grain while a 50mm Forstner cutter did the job but got badly overheated in the process. However, the large positive rake cutters performed well down grain on fine textured woods such as cherry and elm.

Cost comparison has already been made between the changeable positive rake bits and standard forged flat bits and this applies up to the larger sizes of the standard bits. Beyond this a fairer comparison is with woodboring machine bits which at 35mm would cost between £10 and £20 depending upon the type and at 50mm diameter this increases to between £16 and £32. While making no extravagant claims for my cutters I have shown that they will do at least some of the work normally undertaken by these expensive cutters. For example, to check their performance on Formica clad chipboard I drilled a number of holes from 29 to 49mm diameter at 400 rev/min. Entry



Examples of positive rake flat blades.

was perfect and, providing waste backing was well clamped up to the board, so was the exit, yielding a perfect cone of plastic. Shavings came off the formica in a close spiral but a disc of this material had to be released from the cutter (while stationary) on entry before the cut could proceed. It is possible that a lower lead angle would cure this. The hole itself was very highly burnished and dead to size. The life of the scribes on material of this kind would be questionable but certainly long enough for amateur purposes and at 50p instead of £20 well worth considering.

QUICK TIP

Save the U section ribs from old umbrellas – they make excellent woodcarving gouges when fitted with handles!

W. Brian Taylor

